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FREDERICAMYCIN

DERIVATIVES

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-and-

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ENGLISH TRANSLATION

OF

INTERNATIONAL APPLICATION

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## Fredericamycin derivatives

The invention relates to novel fredericamycin derivatives, to drugs containing said derivatives or the salts thereof, and to the use of the fredericamycin derivatives for treating diseases, particularly tumor diseases.

Fredericamycin has been isolated 1981 from *Streptomyces griseus*, and demonstrates anti-tumor activity.

Fredericamycin and some derivatives of fredericamycin are known.

In Heterocycles 37 (1994) 1893 – 1912, J. Am. Chem. Soc. 116 (1994) 9921 – 9926, J. Am. Chem. Soc. 116 (1994) 11275 – 11286, J. Am. Chem. Soc. 117 (1995) 11839 – 11849, JP 2000-072752, and in J. Am. Chem. Soc. 123 (2001), various total syntheses of fredericamycin A have been described, some being enantio-selective.

In US 4673768, alkali salts of the fredericamycin A are described. In US 4584377, fredericamycin derivatives are described, particularly derivatives acylated in ring E and F. In US 5,166,208, fredericamycin derivatives are described as well, particularly derivatives carrying thio and amino substituents in ring F. The derivatives are generated semi-synthetically or fully synthetically.

Surprisingly it was found that fredericamycin derivatives, especially those derivatized in ring A, represent potent drugs. Also, a possibility was found to introduce such residues in ring A semi-synthetically, with which the water solubility and/or the biological effect, the spectrum of action in comparison with fredericamycin, can be significantly increased. Furthermore, an alternative method was found to make fredericamycin and its derivatives water-soluble by generating cyclodextrin inclusion compounds.

The invention relates to novel fredericamycin derivatives with the general Formula Ia or Ib:

(FORMEL) Ia

(FORMEL) Ib

wherein in each,

R1 means H, C<sub>1</sub>-C<sub>6</sub> alkyl, cycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylcycloalkyl,

R2 means H, C<sub>1</sub>-C<sub>14</sub> alkyl, C<sub>2</sub>-C<sub>14</sub> alkenyl, aryl, C<sub>1</sub>-C<sub>4</sub> alkylaryl, heteroaryl, C<sub>1</sub>-C<sub>4</sub> alkyl heteroaryl, C<sub>2</sub>-C<sub>4</sub> alkenylheteroaryl, cycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylcycloalkyl, heterocycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylheterocycloalkyl, C<sub>m</sub>H<sub>2m+o-p</sub>Y<sub>p</sub> (with m = 1 to 6, for o = 1, p = 1 to 2m+o; for m = 2 to 6, o = -1, p = 1 to 2m+o; for m = 4 to 6, o = -2, p = 1 to 2m+o; Y = independently selected from the group consisting of halogen, OH, OR21, NH<sub>2</sub>, NHR21, NR21R22, SH, SR21), (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>NHCOR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>OCOR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>NHCSR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>S(O)<sub>n</sub>R21, with n = 0, 1, 2, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>SCOR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>OSO<sub>2</sub>-R21, (CH<sub>2</sub>)<sub>r</sub>CHO, (CH<sub>2</sub>)<sub>r</sub>CH=NOH, (CH<sub>2</sub>)<sub>r</sub>CH(OH)R21, -(CH<sub>2</sub>)<sub>r</sub>CH=NOR21, (CH<sub>2</sub>)<sub>r</sub>CH=NOCOR21, (CH<sub>2</sub>)<sub>r</sub>CH=NOCH<sub>2</sub>CONR21R22, (CH<sub>2</sub>)<sub>r</sub>CH=NOCH(CH<sub>3</sub>)CONR21R22, - (CH<sub>2</sub>)<sub>r</sub>CH=NOC(CH<sub>3</sub>)<sub>2</sub>CONR21R22, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHCO-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(O)NH-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(S)NH-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(NH)NH-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(NH)-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHCO-CH<sub>2</sub>NHCOR21, (CH<sub>2</sub>)<sub>r</sub>CH=N-O-CH<sub>2</sub>NHCOR21, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHCS-R23, (CH<sub>2</sub>)<sub>r</sub>CH=CR24R25 (trans or cis), (CH<sub>2</sub>)<sub>r</sub>COOH, (CH<sub>2</sub>)<sub>r</sub>COOR21, (CH<sub>2</sub>)<sub>r</sub>CONR21R22, -(CH<sub>2</sub>)<sub>r</sub>CH=NR21, (CH<sub>2</sub>)<sub>r</sub>CH=N-NR21R22, (FORMEL), and the (CH<sub>2</sub>)<sub>r</sub>-chain elongated residue (CH<sub>2</sub>)<sub>r</sub>CH=N-N-(C<sub>3</sub>NX'R211R212R213R214) (with X' = NR215, O, S, and R211, R212, R213, R214, R215 being independently H or C<sub>1</sub>-C<sub>6</sub> alkyl), -(CH<sub>2</sub>)<sub>r</sub>CH=N-NHSO<sub>2</sub> aryl, -(CH<sub>2</sub>)<sub>r</sub>CH=N-NHSO<sub>2</sub> heteroaryl, with r = 0, 1, 2, 3, 4, 5, preferably 0,

R21, R22 are independently H, C<sub>1</sub>-C<sub>14</sub> alkyl, C<sub>1</sub>-C<sub>14</sub> alkanoyl, C<sub>1</sub>-C<sub>6</sub> alkylhydroxy, C<sub>1</sub>-C<sub>6</sub> alkoxy, C<sub>1</sub>-C<sub>6</sub> alkylamino, C<sub>1</sub>-C<sub>6</sub> alkylamino-C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkylamino-di-C<sub>1</sub>-C<sub>6</sub> alkyl, cycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylcycloalkyl, heterocycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylheterocycloalkyl, aryl, aryloyl, C<sub>1</sub>-C<sub>4</sub> alkylaryl, heteroaryl, heteroaryloyl, C<sub>1</sub>-C<sub>4</sub> alkylheteroaryl, cycloalkanoyl, C<sub>1</sub>-C<sub>4</sub> alkanoylcycloalkyl, heterocycloalkanoyl, C<sub>1</sub>-C<sub>4</sub> alkanoylheterocycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkanoylaryl, C<sub>1</sub>-C<sub>4</sub> alkanoylheteroaryl, mono- and di-sugar residues linked through a C atom which would carry an OH residue in the sugar, wherein the sugars are independently selected from the group consisting of glucuronic acid and its stereo isomers at all optical atoms, aldopentoses, aldohexoses, including their desoxy compounds (as e.g. glucose, desoxyglucose, ribose, desoxyribose), or R21 and R22, together with the N, form a ring with

4, 5, 6, 7, or 8 members, which may optionally contain still another heteroatom selected from the group N, O, S,

R23 independently of R21, has the same meanings as R21, or CH<sub>2</sub>-pyridinium salts, CH<sub>2</sub>-tri-C<sub>1</sub>-C<sub>6</sub> alkylammonium salts, CONH<sub>2</sub>, CSNH<sub>2</sub>, CN, CH<sub>2</sub>CN,

R24 independently of R21, has the same meanings as R21, or H, CN, COCH<sub>3</sub>, COOH, COOR21, CONR21R22, NH<sub>2</sub>, NHCOR21,

R25 independently of R21, has the same meanings as R21, or H, CN, COCH<sub>3</sub>, COOH, COOR21, CONR21R22, NH<sub>2</sub>, NHCOR21,

R24, R25 together with the N, form a ring with 4, 5, 6, 7, or 8 members, which may optionally contain still another heteroatom selected from the group N, O, S,

R3 means H, F, Cl, Br, I, OH, OR31, NO<sub>2</sub>, NH<sub>2</sub>, NHR31, NR31R32, NHCHO, NHCOR31, NHCOCF<sub>3</sub>, CH<sub>3-m</sub>hal<sub>m</sub> (with hal = Cl, F, particularly F, and m = 1, 2, 3), OCOR31,

R31, R32 are independently C<sub>1</sub>-C<sub>6</sub> alkyl, or R31 and R32, together with the N, form a ring with 4, 5, 6, 7, or 8 members, which may optionally contain still another heteroatom selected from the group N, O, S,

R5 means H, C<sub>1</sub>-C<sub>20</sub> alkyl, cycloalkyl, C<sub>2</sub>-C<sub>20</sub> alkenyl, C<sub>2</sub>-C<sub>10</sub> alkynyl, C<sub>1</sub>-C<sub>4</sub> alkyl cycloalkyl, heterocycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkyl heterocycloalkyl, aryl, C<sub>1</sub>-C<sub>4</sub> alkylaryl, heteroaryl, C<sub>1</sub>-C<sub>4</sub> alkylheteroaryl, C<sub>m</sub>H<sub>2m+o-p</sub>Y<sub>p</sub> (with m = 1 to 6, for o = 1, p = 1 to 2m+o; for m = 2 to 6, o = -1, p = 1 to 2m+o; for m = 4 to 6, o = -2, p = 1 to 2m+o; Y = independently selected from the group consisting of halogen, OH, OR51, NH<sub>2</sub>, NHR51, NR51R52, SH, SR21), ——— (CH<sub>2</sub>)<sub>s</sub>CH<sub>2</sub>NHCOR51, (CH<sub>2</sub>)<sub>s</sub>CH<sub>2</sub>NHCSR51, (CH<sub>2</sub>)<sub>s</sub>CH<sub>2</sub>S(O)<sub>n</sub>R51, with n = 0, 1, 2, (CH<sub>2</sub>)<sub>s</sub>CH<sub>2</sub>SCOR51, (CH<sub>2</sub>)<sub>s</sub>CH<sub>2</sub>OCOR51, (CH<sub>2</sub>)<sub>s</sub>CH<sub>2</sub>OSO<sub>2</sub>-R51, (CH<sub>2</sub>)<sub>s</sub>CH(OH)R51, (CH<sub>2</sub>)<sub>s</sub>COOH, (CH<sub>2</sub>)<sub>s</sub>COOR51, (CH<sub>2</sub>)<sub>s</sub>CONR51R52, with s = 0, 1, 2, 3, 4, 5, preferably 0, mono- and di-sugar residues linked through a C atom which would carry an OH residue in the sugar, wherein the sugars are independently selected from the group consisting of glucuronic acid and its stereo isomers at all optical atoms, aldopentoses, aldohexoses, including their

desoxy compounds (as e.g. glucose, desoxyglucose, ribose, desoxyribose), with the mono-sugar residues such as aldopentoses, aldohexoses, including their desoxy compounds (as e.g. glucose, desoxyglucose, ribose, desoxyribose) being preferred, with R51, R52 which are capable of independently adopting the meaning of R21, R22,

R4, R6, R7 independently mean H, C<sub>1</sub>-C<sub>6</sub> alkyl, CO-R41,

R41 independently from R21, has the same meanings as R21,

X means O, S, NH, N-R8, wherein R8 independently from R5 may adopt the same meaning as R5, or R5 and R8, together with the N, form a ring with 4, 5, 6, 7, or 8 members, which may optionally contain still another heteroatom selected from the group N, O, S,

or X-R5 may together be H,

Y means O, S, NR9, wherein R9 may be H or C<sub>1</sub>-C<sub>6</sub> alkyl,

as well their stereoisomers, tautomers, and their physiologically tolerable salts or inclusion compounds, wherein the residues for Formula Ia may not concomitantly adopt the following meaning, except in case of cyclodextrin inclusion compounds: R1: H, C<sub>1</sub>-C<sub>6</sub> alkyl, R2: C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>2</sub>-C<sub>6</sub> alkenyl, R3: H, R4 and R6 identical, and independently H, C<sub>1</sub>-C<sub>6</sub> alkyl, CO-R41, with R41 being C<sub>1</sub>-C<sub>6</sub> alkyl, aryl, and R7 being H, C<sub>1</sub>-C<sub>6</sub> alkyl, Y: O, and for Formula Ib: R1: H, R2: pentyl, 1-pentenyl, 3-pentenyl, 1,3-pentdienyl, R3: H, R4 and R6 being H, and X-R5 being methoxy, Y: O. Preferably, the substituents do not concomitantly adopt the following meaning: R1, R3: H, R2: H, alkyl, hydroxyalkyl, particularly monohydroxyalkyl, alkoxyalkyl, CF<sub>3</sub>, (CH<sub>2</sub>)<sub>r</sub>COOH, CHO, CONH<sub>2</sub>, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>NHCO alkyl, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>OCO alkyl, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>NHCS alkyl, CH≡NOH, CH≡NO alkyl, aryl, alkylaryl, alkylheteroaryl, alkenyl, hydroxyalkenyl, particularly monohydroxyalkenyl, R4, R6, R7: H, alkyl, X-R5: H, R5: H, alkyl, aryl.

Preferred are compounds of Formula IIa or IIb

(FORMEL) IIa

## (FORMEL) IIb

wherein the meaning of the residues R1-R41, X is as described above, their tautomers and their physiologically tolerable salts or inclusion compounds, wherein the residues for Formula Ia may not concomitantly adopt the following meaning, except in the case of cyclodextrin inclusion compounds: R1: H, C<sub>1</sub>-C<sub>6</sub> alkyl, R2: C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>2</sub>-C<sub>6</sub> alkenyl, R3: H, R4 and R6 identical, and independently H, C<sub>1</sub>-C<sub>6</sub> alkyl, CO-R41, with R41 being C<sub>1</sub>-C<sub>6</sub> alkyl, aryl, and R7 being H, C<sub>1</sub>-C<sub>6</sub> alkyl, Y: O, and for Formula Ib: R1: H, R2: pentyl, 1-pentenyl, 3-pentenyl, 1,3-pentadienyl, R3: H, R4 and R6 being H, and X-R5 being methoxy, Y: O.

The invention further relates to compounds of Formula Ia, Ib, IIa or IIb, in which the residues R, except for R2, have the above described meanings, and the water solubility of R2 is at least two times higher, preferably at least five times higher, more preferred at least ten times higher, especially preferred at least fifty times higher, particularly one hundred times higher, or even five hundred times higher than of R2 being CH=CH-CH=CH-CH<sub>3</sub>, when all other residues are maintained. The increase in the water solubility is achieved e.g. by introduction of groups which can form additional hydrogen bonds, and/or are polar, and/or are ionic. A key intermediate are compounds with an aldehyde function in R2.

For R2 preferred is also the group of the residues C<sub>m</sub>H<sub>2m+o-p</sub>Y<sub>p</sub> (with m = 1 to 6, for o = 1, p = 1 to 2m+o; for m = 2 to 6, o = -1, p = 1 to 2m+o; for m = 4 to 6, o = -2, p = 1 to 2m+o; Y = independently selected from the group of halogen, OH, OR21, NH<sub>2</sub>, NHR21, NR21R22, SH, SR21), (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>NHCOR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>OCOR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>NHCSR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>S(O)nR21, with n = 0, 1, 2, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>SCOR21, (CH<sub>2</sub>)<sub>r</sub>CH<sub>2</sub>OSO<sub>2</sub>-R21, (CH<sub>2</sub>)<sub>r</sub>CH(OH)R21, (CH<sub>2</sub>)<sub>r</sub>COOH, (CH<sub>2</sub>)<sub>r</sub>COOR21, (CH<sub>2</sub>)<sub>r</sub>CONR21R22. Still particularly preferred is the group of the aldehyde-derived residues (CH<sub>2</sub>)<sub>r</sub>CHO, (CH<sub>2</sub>)<sub>r</sub>CH=NOH, - (CH<sub>2</sub>)<sub>r</sub>CH=NOR21, - (CH<sub>2</sub>)<sub>r</sub>CH=NOCOR21, (CH<sub>2</sub>)<sub>r</sub>CH=NOCH<sub>2</sub>CONR21R22, - (CH<sub>2</sub>)<sub>r</sub>CH=N-NHCO-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(O)NH-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(S)NH-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(NH)NH-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHC(NH)-R23, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHCO-CH<sub>2</sub>NHCOR21, (CH<sub>2</sub>)<sub>r</sub>CH=N-O-CH<sub>2</sub>NHCOR21, (CH<sub>2</sub>)<sub>r</sub>CH=N-NHCS-R23, (CH<sub>2</sub>)<sub>r</sub>CH=CR24R25 (trans or cis), (CH<sub>2</sub>)<sub>r</sub>CH=NR21, (CH<sub>2</sub>)<sub>r</sub>CH=N-NR21R22, (FORMEL), and the (CH<sub>2</sub>)<sub>r</sub>-chain elongated residue (CH<sub>2</sub>)<sub>r</sub>CH=N-N-(C<sub>3</sub>NX'R211R212R213R214) (with X' = NR215, O, S, and R211, R212, R213, R214, R215 being independently H or C<sub>1</sub>-C<sub>6</sub> alkyl), - (CH<sub>2</sub>)<sub>r</sub>CH=N-NHSO<sub>2</sub> aryl,

$(\text{CH}_2)_r\text{CH}=\text{N}-\text{NHSO}_2$  heteroaryl,  $(\text{CH}_2)_r\text{CH}=\text{CH}$  heteroaryl, with  $r = 0, 1, 2, 3, 4, 5$ , preferably 0.

From the aldehydes and thereof derived compounds, such are preferred in which at least R1 or R3 are not H, if R4 to R7 are H or alkyl.

Preferred residues in R2 are further heteroaryl, cycloaryl,  $\text{C}_1\text{-C}_4$  alkylcycloalkyl, heterocycloalkyl,  $\text{C}_1\text{-C}_4$  alkyl heterocycloalkyl,  $\text{C}_m\text{H}_{2m+o-p}\text{Y}_p$  (with  $m = 1$  to 6, for  $o = 1$ ,  $p = 1$  to  $2m+o$ ; for  $m = 2$  to 6,  $o = -1$ ,  $p = 1$  to  $2m+o$ ; for  $m = 4$  to 6,  $o = -2$ ,  $p = 1$  to  $2m+o$ ; Y = independently selected from the group of halogen, OH, OR21,  $\text{NH}_2$ , NHR21, NR21R22, SH, SR21),  $\text{CH}_2\text{NHCOR21}$ ,  $\text{CH}_2\text{NHCSR21}$ ,  $\text{CH}_2\text{S(O)}_n\text{R21}$ , with  $n = 0, 1, 2$ ,  $\text{CH}_2\text{SCOR21}$ ,  $\text{CH}_2\text{OSO}_2\text{-R21}$ ,  $\text{CH(OH)R21}$ ,  $\text{CH}=\text{NOCOR21}$ ,  $-\text{CH}=\text{NOCH}_2\text{CONR21R22}$ ,  $-\text{CH}=\text{NOCH(CH}_3\text{)-CONR21R22}$ ,  $\text{CH}=\text{NOC(CH}_3\text{)}_2\text{CONR11R22}$ ,  $\text{CH}=\text{N-NHCO-R23}$ ,  $-\text{CH}=\text{N-NHCO-CH}_2\text{NHCOR21}$ ,  $\text{CH}=\text{N-O-CH}_2\text{NHCOR21}$ ,  $-\text{CH}=\text{N-NHCS-R23}$ ,  $\text{CH}=\text{CR24R25}$  (trans or cis), CONR21R22,  $-\text{CH}=\text{NR21}$ ,  $-\text{CH}=\text{N-NR21R22}$ , (FORMEL), with  $\text{X}' = \text{NR215}$ , O, S, and R211, R212, R213, R214, R215 being independently H or  $\text{C}_1\text{-C}_6$  alkyl),  $\text{CH}=\text{N-NHSO}_2$  aryl,  $\text{H}=\text{N-NHSO}_2$  heteroaryl.

Furthermore, compounds as described above are preferred, in which R3 means F, Cl, Br, I, OH, OR31,  $\text{NO}_2$ ,  $\text{NH}_2$ , NHR31, NR31R32, NHCHO, NHCOR31,  $\text{NHCOCF}_3$ ,  $\text{CH}_3\text{-}_m\text{hal}_m$  (with  $\text{hal} = \text{Cl, F}$ , particularly F, and  $m = 1, 2, 3$ ), OCOR31, with the above described meanings for R31, R32.

Also preferred are compounds as described above, in which X means N or S, especially when R3 is H or halogen, and/or R2 is alkenyl, particularly butadienyl or 1, 3-pentdienyl.

Also preferred are compounds as described above, in which X-R5 is OH, and particularly their salts, and preferred in compounds of Formula Ia or IIa, since this acidic OH group may easily be deprotonized, which increases the water solubility and/or the biological efficacy.

Furthermore preferred are still compounds as described above, wherein the residues R preferably independently adopt one or more of the following meanings:

R1 means H,  $\text{C}_1\text{-C}_5$  alkyl, cycloalkyl, especially H,

R2 means C<sub>1</sub>-C<sub>5</sub> alkyl, C<sub>1</sub>-C<sub>4</sub> alkylaryl, C<sub>2</sub>-C<sub>5</sub> alkenyl, heteroaryl, C<sub>1</sub>-C<sub>4</sub> alkylheteroaryl, C<sub>2</sub>-C<sub>4</sub> alkenylheteraryl, CHF<sub>2</sub>, CF<sub>3</sub>, polyol side chain, particularly CHOH-CHOH-CHOH-CHOH-CH<sub>3</sub>, CHOH-CHOH-CH=CH-CH<sub>3</sub>, CH=CH-CHOH-CHOH-CH<sub>3</sub>, CH<sub>2</sub>Y (Y = F, Cl, Br, I), CH<sub>2</sub>NH<sub>2</sub>, CH<sub>2</sub>NR<sub>21</sub>R<sub>22</sub>, CH<sub>2</sub>NHCOR<sub>23</sub>, CH<sub>2</sub>NHCSR<sub>23</sub>, CH<sub>2</sub>SH, CH<sub>2</sub>S(O)<sub>n</sub>R<sub>21</sub>, with n = 0, 1, 2, CH<sub>2</sub>SCOR<sub>21</sub>, particularly CH<sub>2</sub>OH, CH<sub>2</sub>OR<sub>21</sub>, CH<sub>2</sub>OSO<sub>2</sub>-R<sub>21</sub>, particularly CHO, CH(OR<sub>21</sub>)<sub>2</sub>, CH(SR<sub>21</sub>)<sub>2</sub>, CN, CH=NOH, CH=NOR<sub>21</sub>, CH=NOCOR<sub>21</sub>, CH=N-NHCO-R<sub>32</sub>, CH=CR<sub>24</sub>, R<sub>25</sub> (trans or cis), particularly COOH (particularly their physiologically tolerable salts), COOR<sub>21</sub>, CONR<sub>21</sub>R<sub>22</sub>, -CH=NR<sub>21</sub>, -CH=N-NR<sub>21</sub>R<sub>22</sub>, (FORMEL), (with X' = NR<sub>215</sub>, O, S, and R<sub>211</sub>, R<sub>212</sub>, R<sub>213</sub>, R<sub>214</sub>, R<sub>215</sub> being independently H or C<sub>1</sub>-C<sub>6</sub> alkyl), -CH=N-NHSO<sub>2</sub> aryl, -CH=N-NHSO<sub>2</sub> heteroaryl, CH=N-NHCO-R<sub>23</sub>,

R<sub>21</sub>, R<sub>22</sub> independently mean C<sub>1</sub>-C<sub>6</sub> alkyl, cycloalkyl, aryl, C<sub>1</sub>-C<sub>4</sub> alkylaryl, heteroaryl, C<sub>1</sub>-C<sub>4</sub> alkylheteroaryl,

R<sub>23</sub> independently of R<sub>21</sub>, has the same meanings as R<sub>21</sub>, or CH<sub>2</sub>-pyridinium salts, CH<sub>2</sub>-tri-C<sub>1</sub>-C<sub>6</sub> alkylammonium salts,

R<sub>24</sub> independently of R<sub>21</sub>, has the same meanings as R<sub>21</sub>, or H, CN, COCH<sub>3</sub>, COOH, COOR<sub>21</sub>, CONR<sub>21</sub>R<sub>22</sub>, NH<sub>2</sub>, NHCOR<sub>21</sub>,

R<sub>25</sub> independently of R<sub>21</sub>, has the same meanings as R<sub>21</sub>, or H, CN, COCH<sub>3</sub>, COOH, COOR<sub>21</sub>, CONR<sub>21</sub>R<sub>22</sub>, NH<sub>2</sub>, NHCOR<sub>21</sub>,

R<sub>24</sub>, R<sub>25</sub> together mean C<sub>4</sub>-C<sub>8</sub> cycloalkyl,

R<sub>3</sub> means F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, NHCOR<sub>31</sub>,

R<sub>31</sub> independently means C<sub>1</sub>-C<sub>6</sub> alkyl,

R<sub>5</sub> means H, C<sub>1</sub>-C<sub>6</sub> alkyl, particularly C<sub>1</sub>-C<sub>3</sub> alkyl, C<sub>3</sub>-C<sub>8</sub> cycloalkyl, C<sub>3</sub>-C<sub>8</sub> cycloalkenyl, C<sub>1</sub>-C<sub>6</sub> alkenyl, C<sub>1</sub>-C<sub>6</sub> alkynyls, C<sub>1</sub>-C<sub>4</sub> alkylcycloalkyl, heterocycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylheterocycloalkyl, aryl, C<sub>1</sub>-C<sub>4</sub> alkylaryl, heteroaryl, C<sub>1</sub>-C<sub>4</sub> alkylheteroaryl, C<sub>m</sub>H<sub>2m+o-p</sub>Y<sub>p</sub> (with m = 1 to 6, for o = 1, p = 1 to 2m+o; for m = 2 to 6, o = -1, p = 1 to 2m+o; for m = 4 to



6,  $o = -2$ ,  $p = 1$  to  $2m+o$ ;  $Y$  = independently selected from the group consisting of halogen, OH, OR21, NH<sub>2</sub>, NHR21, NR21R22, SH, SR21), particularly preferred is hydroxyalkyl with one or more OH groups,

R4, R6, R7 independently means H, C<sub>1</sub>-C<sub>5</sub> alkyl, CO-R41,

R41 independently from R21, has the same meanings as R21,

X means O, S, NH, N-R8,

Y means O, S, NH,

as well their stereoisomers, tautomers, and their physiologically tolerable salts or inclusion compounds, wherein the residues for Formula Ia may not concomitantly adopt the following meaning, except in case of cyclodextrin inclusion compounds: R1: H, C<sub>1</sub>-C<sub>6</sub> alkyl, R2: C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>2</sub>-C<sub>6</sub> alkenyl, R3: H, R4 and R6 are identical, and independently are H, C<sub>1</sub>-C<sub>6</sub> alkyl, CO-R41, with R41 being C<sub>1</sub>-C<sub>6</sub> alkyl, aryl, and R7 being H, C<sub>1</sub>-C<sub>6</sub> alkyl, and for Formula Ib: R1: H, R2: pentyl, 1-pentenyl, 3-pentenyl, 1,3-pentadienyl, R3: H, R4 and R6 being H, and X-R5 being methoxy.

O, S, particularly O, are preferred for Y.

O, NH, N-R8 are preferred for X.

H, methyl, ethyl, propyl, particularly methyl, are preferred for R5.

H, methyl, ethyl, propyl, particularly methyl, are preferred for R8.

OCH<sub>3</sub>, NH<sub>2</sub>, N(CH<sub>3</sub>)<sub>2</sub> are preferred for XR5.

For R2 also preferred is the residue -CHOHCHOHCHOHCHOHCH<sub>3</sub>.

Furthermore, the following residues are preferred for R2: -CHCH-2-methyl-4-thiazyl, particularly (FORMEL), wherein R particularly is alkyl or NHCO alkyl, CH=NOR21, with

R21 being methyl, ethyl, n-propyl, isopropyl, n-butyl, n-hexyl, benzyl, halogen benzyl, particularly fluorobenzyl and chlorobenzyl,  $-\text{CH}_2\text{CH}_2$  morpholinyl.

Especially preferred are the compounds, the stereo isomers, tautomers, and physiologically tolerable salts or inclusion compounds of which, selected from the group consisting of the compounds of the examples and the compounds, demonstrate combinations of the various substituents of the examples.

Particularly preferred for R3 is H, F, Cl, Br, J, particularly F, Cl, Br, J.

Particularly preferred for R2 is  $\text{C}_1\text{-C}_8$  alkyl,  $\text{C}_2\text{-C}_8$  alkenyl,  $\text{CH}=\text{NOR1}$ , with R21 being  $\text{C}_1\text{-C}_8$  alkyl,  $\text{C}_1\text{-C}_8$  alkenyl, aryl or heteroaryl,  $\text{C}_1\text{-C}_2$  alkylaryl, particularly benzyl,  $\text{C}_1\text{-C}_2$  alkylheteroaryl, wherein aryl or heteroaryl in particular have only one ring system which may be substituted once or twice with a substituent such as halogen, methyl,  $\text{CF}_3$ , OH, OMe.

Particularly preferred are derivatives of fredericamycin A in which only the above indicated, particularly preferred meanings of R2 and/or R3 are realized.

The invention furthermore relates to drugs containing the above compounds of Formula I or II together with the usual carriers and adjuvants.

Also preferred are the above mentioned drugs in combination with other agents for tumor treatment.

These compounds according to the invention are used for preparation of drugs for treatment of tumors, particularly such that may be treated by inhibition of the topoisomerases I and/or II. Tumors that can be treated with the substances according to the invention are e.g. leukemia, lung cancer, melanomas, uterus tumors, prostate tumors and colon tumors.

Also, fredericamycin A and its derivatives act against an unknown target in the cell cycle leading to apoptosis in tumor cells.

Furthermore, the compounds according to the invention, and compounds which have concomitantly adopted the following meanings in Formula Ia: R1: H,  $\text{C}_1\text{-C}_6$  alkyl, R2:  $\text{C}_1\text{-C}_6$

alkyl, C<sub>2</sub>-C<sub>6</sub> alkenyl, R<sub>3</sub>: H, R<sub>4</sub> and R<sub>6</sub> identically and independently H, C<sub>1</sub>-C<sub>6</sub> alkyl, CO-R<sub>41</sub>, with R<sub>41</sub> being C<sub>1</sub>-C<sub>6</sub> alkyl, aryl, and R<sub>7</sub> being H, C<sub>1</sub>-C<sub>6</sub> alkyl, and in Formula Ib: R<sub>1</sub>: H, R<sub>2</sub>: pentyl, 1-pentenyl, 3-pentenyl, 1,3-pentdienyl, R<sub>3</sub>: H, R<sub>4</sub> and R<sub>6</sub> being H and X-R<sub>5</sub> being methoxy, are used for preparation of drugs for treatment of neurodermitis, parasites and for immunosuppression.

The invention also relates to a method for preparation of fredericamycin derivatives in which R<sub>2</sub> as intermediate is  $\text{-CHOHCHOHCHOHCHOHCH}_3$ . These compounds are preferably transformed into aldehydes for further derivatization.

In the description and the claims, the substituents are described by the following definitions:

The term "alkyl" by itself or as part of another substituent means a linear or branched alkyl chain radical of the respectively indicated length, in which optionally a CH<sub>2</sub> group may be substituted by a carbonyl function. Thus, C<sub>1-4</sub> alkyl may be methyl, ethyl, 1-propyl, 2-propyl, 2-methyl-2-propyl, 2-methyl-1-propyl, 1-butyl, 2-butyl, C<sub>1-6</sub> alkyl, e.g. C<sub>1-4</sub> alkyl, pentyl, 1-pentyl, 2-pentyl, 3-pentyl, 1-hexyl, 2-hexyl, 3-hexyl, 4-methyl-1-pentyl, or 3,3-dimethylbutyl.

The term "C<sub>1</sub>-C<sub>6</sub> alkylhydroxy" by itself or as part of another substituent means a linear or branched alkyl chain radical of the respectively indicated length which may be saturated or unsaturated, and which carries an OH group, e.g. hydroxymethyl, hydroxymethyl, 1-hydroxypropyl, 2-hydroxypropyl.

The term "alkenyl" by itself or as part of another substituent means a linear or branched alkyl chain radical with one or more C=C double bonds of the respectively indicated length, several double bonds being preferably conjugated. Thus, C<sub>2-6</sub> alkenyl may for example be ethenyl, 1-propenyl, 2-propenyl, 2-methyl-2-propenyl, 2-methyl-1-propenyl, 1-butenyl, 2-butenyl, 1,3-butdienyl, 2,4-butdienyl, 1-pentenyl, 2-pentenyl, 3-pentenyl, 1,3-pentdienyl, 2,4-pentdienyl, 1,4-pentdienyl, 1-hexenyl, 2-hexenyl, 1,3-hexadienyl, 4-methyl-1-pentenyl, or 3,3-dimethylbutenyl.

The term "alkinyl" by itself or as part of another substituent means a linear or branched alkyl chain radical with one or more C-C triple bonds of the respectively indicated length. Thus, C<sub>2-6</sub> alkinyl may for example be ethynyl, 1-propynyl, 2-propynyl, 2-methyl-2-propynyl, 2-methyl-

1-propinyl, 1-butenyl, 2-butenyl, 1,3-butdiinyl, 2,4-butdiinyl, 1-pentynyl, 2-pentynyl, 3-pentynyl, 1-hexinyl, 2-hexinyl, 4-methyl-1-pentynyl, or 3,3-dimethylbutynyl.

The term "halogen" stands for fluorine, chlorine, bromine, iodine, preferably bromine and chlorine.

The term "NR<sub>2</sub>IR<sub>2</sub>" preferably stands for a dialkylamino group, wherein the two alkyl groups together with the N can form a ring with 5 or 6 members with optionally one more heteroatom N or O.

The term "cycloalkyl" by itself or as part of another Substituent comprises unsaturated (mono or poly, preferably mono) or saturated, cyclic carbohydrate groups with 3 to 10 C atoms, preferably 3 to 8 C atoms, such as e.g. cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cyclohex-2-enyl, cyclohex-3-enyl, cyclohex-2,4-dienyl, 4-methylcyclohexyl, 3-methylcyclohexyl, cycloheptyl or cyclooctyl. Saturated cycloalkyls are preferred. The cycloalkyls may be substituted with up to 3 substituents, preferably with up to 1 substituent, wherein the substituents independently can have the meaning C<sub>1</sub>-C<sub>6</sub> alkyl, OH, NO<sub>2</sub>, CN, CF<sub>3</sub>, OR<sub>11</sub>, SH, SR<sub>11</sub>, C<sub>1</sub>-C<sub>6</sub> alkylhydroxy, C<sub>1</sub>-C<sub>6</sub> alkyl-OR<sub>11</sub>, COOH, COOR<sub>11</sub>, NH<sub>2</sub>, NHR<sub>11</sub>, NR<sub>11</sub>R<sub>12</sub>, halogen, aryl, C<sub>1</sub>-C<sub>4</sub> alkylaryl, heteroaryl, C<sub>1</sub>-C<sub>4</sub> heteroalkylaryl, wherein the residues R<sub>11</sub> und R<sub>12</sub> independently can mean C<sub>1</sub>-C<sub>10</sub> alkyl, cycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylcycloalkyl.

The term "heterocycloalkyl" by itself or as part of another substituent includes cycloalkyl groups, wherein up to two CH<sub>2</sub> groups may be substituted by oxygen, sulfur or nitrogen atoms, and one or two other CH<sub>2</sub> groups may be substituted by one or two carbonyl function(s), carbothionyl function(s), or a carbonyl function and a carbothionyl function, for example pyrrolidine, piperidine, morpholine or

FORMEL	FORMEL Y = CH <sub>2</sub> , S, O NH, NC <sub>1</sub> -C <sub>6</sub> alkyl	FORMEL
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The heterocycloalkyls may be substituted as with the cycloalkyls.

The term "aryl" by itself or as part of another substituent includes aromatic ring systems with up to 3 rings, in which at least 1 ring system is aromatic, and those with up to 3 substituents, preferably up to 1 substituent, wherein the substituents independently can have the meaning C<sub>1</sub>-C<sub>6</sub> alkyl, OH, NO<sub>2</sub>, CN, CF<sub>3</sub>, OR<sub>11</sub>, SH, SR<sub>11</sub>, C<sub>1</sub>-C<sub>6</sub> alkylhydroxy, C<sub>1</sub>-C<sub>6</sub> alkyl-OR<sub>11</sub>, COOH, COOR<sub>11</sub>, NH<sub>2</sub>, NHR<sub>11</sub>, NR<sub>11</sub>R<sub>12</sub>, halogen, wherein the residues R<sub>11</sub> and R<sub>12</sub> independently can mean C<sub>1</sub>-C<sub>10</sub> alkyl, cycloalkyl, C<sub>1</sub>-C<sub>4</sub> alkylcycloalkyl, or R<sub>11</sub> and R<sub>12</sub>, together with the N, form a ring with 4, 5, 6, 7 or 8 members optionally containing still another heteroatom selected from the group N, O, S.

Apart from phenyl and 1-naphthyl and 2-naphthyl, preferred aryls are:

FORMEL					
FORMEL					

The term "heteroaryl" by itself or as part of another substituent includes aromatic ring systems with up to 3 rings and with up to 3 identical or different heteroatoms N, S, O, in which at least 1 ring system is aromatic, and those with up to 3 substituents, preferably up to 1 substituent, wherein the substituents independently can have the meaning C<sub>1</sub>-C<sub>6</sub> alkyl, OH, NO<sub>2</sub>, CN, CF<sub>3</sub>, OR<sub>11</sub>, SH, SR<sub>11</sub>, C<sub>1</sub>-C<sub>6</sub> alkylhydroxy, C<sub>1</sub>-C<sub>6</sub> alkyl-OR<sub>11</sub>, COOH, COOR<sub>11</sub>, NH<sub>2</sub>, NHCOR<sub>11</sub>, NHR<sub>11</sub>, NR<sub>11</sub>R<sub>12</sub>, halogen, or phenyl, wherein the residues R<sub>11</sub> and R<sub>12</sub> independently can have the above indicated meanings.

Preferred heteroaryls are:

FORMEL					
FORMEL					
FORMEL					
FORMEL					

The term "ring system" generally refers to rings with 3, 4, 5, 6, 7, 8, 9, or 10 members. Preferred are rings with 5 and 6 members. Furthermore, ring systems with one or 2 annelated rings are preferred.

The compounds of Formula I may be present as such, or, if they contain acidic or basic groups, in the form of their salts with physiologically tolerable bases or acids. Examples for such acids are: hydrochloric acid, citric acid, trifluoroacetic acid, tartaric acid, lactic acid, phosphoric acid, methane sulfonic acid, acetic acid, formic acid, maleic acid, fumaric acid, succinic acid, hydroxysuccinic acid, sulfuric acid, glutaric acid, aspartic acid, pyruvic acid, benzoic acid, glucuronic acid, oxalic acid, ascorbic acid, and acetylglycine. Examples for bases are alkali ions, preferably Na, K, particularly preferred the tri-potassium and tri-sodium salts, alkaline earth ions, preferably Ca, Mg, ammonium ions.

The compounds according to the invention may be administered orally in the usual way. The application may also be i.v., i.m., with vapors, or sprays through the nasopharynx.

The dosage depends on age, condition and weight of the patient as well as on the type of application. Usually, the daily dose of the active ingredient per person is between 0.1 µg/kg and 1 g/kg orally. This dosage may be given as 2 to 4 split dosages, or once per day as a slow release form.

The novel compounds may be used in the usual solid or liquid pharmaceutical application forms, e.g. as tablets, film tablets, capsules, powder, granules, coated tablets, solutions, or sprays. These are produced in the usual way. The agents can be processed with the usual pharmaceutical adjuvants such as tablet binders, fillers, preservatives, disintegrants, flow regulators, plasticizers, wetting agents, dispersants, emulsifiers, solvents, retardation agents, antioxidants, and/or propellants (see H. Sucker et al.: Pharmazeutische Technologie, Thieme-Verlag, Stuttgart, 1978). Usually, the so obtained application forms contain the active ingredient in amounts of 0.1 to 99 percent per weight.

#### **Experimental Part**

Fredericamycin A can be prepared by fermentation or fully synthetically according to the known methods. The reduced forms of the Formulas Ib and IIb can be obtained from the appropriate compounds of Formulas Ia and IIa using mild reducing agents.

#### **Preparation of the substances**

For synthesis of water soluble fredericamycin derivatives, fredericamycin (1) was first hydroxylized with osmium(IV)oxide at the diene side chain. The resulting compound (2)

shows significantly higher water solubility compared to the original compound fredericamycin (1). In order to further increase the water solubility, (2) was transformed into the tri-potassium salt (3) (see diagram 1).

#### Diagram 1

(FORMEL)

- a)  $\text{OsO}_4$ , N-methylmorpholine-N-oxide,  $\text{CH}_2$ ,  $\text{Cl}_2$ ,  $\text{CH}_3\text{OH}$ ,  $\text{H}_2\text{O}$
- b) KOH pyridine

The fredericamycin tetrol (2) serves, among others, as an important intermediate for the synthesis of other fredericamycin derivatives with increased solubility and/or better action profile. By iodate cleavage with sodium periodate or carrier-bound periodate, the tetrol side chain may be degraded with very high yields to fredericamycin aldehyde (4) (see diagram 2).

#### Diagram 2

(FORMEL)

- a)  $\text{NaIO}_4\text{-H}_2\text{O-DMF}$  or carrier bound  $\text{-IO}_4\text{-H}_2\text{O-DMF}$

The fredericamycin aldehyde (4) can be reacted with acylhydrazones, hydroxylamine, and O-alkylhydroxylamine to the appropriate hydrazone (see diagram 3), or oxime and oximether (see diagram 4). The reaction can be performed at room temperature in solvents such as DMF or pyridine, and is finished after a few minutes to hours.

#### Synthesis of hydrazones

##### Diagram 3

(FORMEL)

(4)

(table 1/3)

#### Table 1

<u>Example/compound</u>	<u>R</u>	<u>m/e</u>	<u><math>\lambda_{\max}(\text{nm})</math></u>
<u>5/118</u>	FORMEL	601.3	504.0
<u>6/119</u>	FORMEL	635.2	486.0

(FORMEL)

<u>R</u>	<u>Compound</u>	<u>Example</u>
FORMEL	111	18
FORMEL	105	19
FORMEL	113	20

**Synthesis of oximether**

Diagram 4

(FORMEL)

(4)

(table 2/3)

Table 2

<u>Example/compound</u>	<u>R</u>	<u>m/e</u>	<u><math>\lambda_{\max}(\text{nm})</math></u>
7/122	-H	516.1	500.0
8/120	-CH <sub>3</sub>	531.2	500.0
9/121	FORMEL	607.2	504.0
10/123	FORMEL	678.1	504.0
21/116	FORMEL	630.1	504.0

Analogously, the compounds 100 – 242 can be generated according to the instructions below (table 3). The hereby used hydrazines, hydrazones and hydroxylamines are available commercially, or have been produced according to instructions known from the literature.

Diagram 5

(FORMEL)

(R1= halogen, I, Br, Cl)

(table 3)



Table 3

Formula for table 3:

(FORMEL)

Example/Compound	R1	R2	Calculated mass	Actual mass	UV <sub>max</sub>	Yield
100	C5H5N2	H	592.1230	593.10	500	95
...	FORMEL					
...						
242	C2H3N2O2	I	711.9897	713.37	500	99

**Reduction and oxidation of fredericamycin aldehyde (4)**

Fredericamycin aldehyde (4) can be reacted with a common reducing agent such as sodium borohydride in a solvent such as DMF or pyridine to hydroxymethyl fredericamycin (11). The reaction can be summarized as a single pot reaction (iodate cleavage of fredericamycin tetrol (2) to fredericamycin aldehyde (4) (see diagram 2) and reduction without isolation of the intermediates to fredericamycin alcohol (11)).

## Diagram 5

(FORMEL)

- NaClO<sub>2</sub>, NaH<sub>2</sub>PO<sub>4</sub>, 2,3-dimethylbutene-2
- KOH, -H<sub>2</sub>O, DMF
- NaBH<sub>4</sub>

Fredericamycin aldehyde (4) can be oxidized with the oxidizing agent sodium chlorite (NaClO<sub>2</sub>), a buffer such as sodium dihydrogenphosphate in presence of an alkene such as 2,3-dimethylbutene with very good yields to fredericamycin carboxylic acid (12). The usually employed oxidation methods such as those being used in preparative chemistry for the oxidation of aldehydes to carboxylic acids (oxidation with chromium(VI) compounds, manganese(VII) compounds as well as peroxo acid) did not lead to success. Only the use of the above described oxidation method provided the desired product. The literature describes oxidations of 2-pyridone-6-aldehydes with silver ions and potassium permanganate in an

alkaline medium. This method, however, is not suited for fredericamycin and its derivatives since fredericamycin (1) contains base-labile (-reactive) groups (OH groups) causing undesired side reactions.

The potassium salt of the fredericamycin acid (13) was obtained according to a common method by stoichiometric neutralization.

### Substitution in the B ring

Fredericamycin (1) can be reacted with halogenation agents such as N-bromosuccinimide (NBS) and N-iodosuccinimide (NIS) with good yields to the substituted 5-bromo or 5-iodo fredericamycin derivatives (14) and (15) (diagram 6). The fredericamycin aldehyde (4) and (36) can be transformed with elemental bromine, NBS, BrI, NIS, and NCS to the appropriate halogen-substituted fredericamycin aldehyde (37), (38) and (39).

The appropriate fluorine compound is accessible, too.

Diagram 6  
(FORMEL)

- a) N-bromosuccinimide, DMF, 0° C;
- b) N-iodosuccinimide, DMF, 0° C;

(FORMEL)

...

fredericamycin aldehyde -----→ Br<sub>2</sub> or Cl-I-----→

---

Both of the two following fredericamycin compounds (23) and (24) are also precursors. (23) is the precursor for an amino acid-linked fredericamycin derivative.

The preparation of (23) may be recognized as proof that the aldehyde (4) may be reacted with phosphorylides according to Wittig or Wittig-Horner (see diagram 7).

Diagram 7  
(FORMEL)

a) (FORMEL) Tetramethylguanidine

The compound (24) is the precursor of an N-methylated fredericamycin derivative (diagram 8).

Diagram 8  
(FORMEL)

a)  $\text{CH}_3\text{I}$ ,  $\text{K}_2\text{CO}_3$ , DMF, RT

Fredericamycin may be transformed by palladium/hydrogen almost quantitatively to tetrahydro fredericamycin (25), and may be halogenated in the nucleus according to the above described methods, e.g. to the bromine compound (26) (diagram 9):

Diagram 9  
(FORMEL)

Surprisingly it has also been found that the methoxy groups in fredericamycin and the derivatives according to the invention can be exchanged under alkali or earth alkali acetate catalysis by oxygen nucleophiles such as alcohols or polyols. Thereby, the alcohols can carry a multitude of different substituents (table 4).

Diagram 10  
(FORMEL)

Table 4

Example	R1	R2	R3	UV <sub>max</sub> (nm)	m/e	Yield (%)
243	FORMEL	H	FORMEL	504	(M+H) 554	97
244	FORMEL	H	FORMEL	500	(M+) 582	96

245	FORMEL	H	FORMEL	500	(M+H) 568	70
246	FORMEL	H	FORMEL	504	(M+H) 597	36
247	FORMEL	Br	FORMEL	504	(M+) 632/634	71
248	FORMEL	H	FORMEL	500	(M+H) 566	91
249	FORMEL	H	FORMEL	499	(M+) 569	52
250	FORMEL	H	FORMEL	504	(M+H) 616	99
251	FORMEL	H	FORMEL	500	(M+) 580	99
252	FORMEL	H	FORMEL	499	(M+H) 622	20
253	FORMEL	H	FORMEL	500	(M+H) 669	99
254	FORMEL	H	FORMEL	504	(M+H) 653	48
255	FORMEL	H	FORMEL	504	(M+H) 594	50
256	FORMEL	H	FORMEL	499	(M+H) 632/634	99

#### Exchange of the methoxy group at the F ring

The exchange of the methoxy groups at the F ring of the fredericamycin and at the derivatives is possible by primary, secondary or aromatic amines. Thereby, the components are stirred with the appropriate primary or secondary amines at room temperature in DMF or in another inert solvent. With aromatic amines, a catalysis with Lewis acids such as stannous(IV)chloride, etc. is required.

Diagram 11

(FORMEL)

Table 5

R1	FORMEL	Example
I	FORMEL	257
I	FORMEL	258
Br	FORMEL	259
H	FORMEL	260
H	FORMEL	261
H	FORMEL	262
H	FORMEL	263

H	FORMEL	264
H	FORMEL	265
I	FORMEL	266
H	FORMEL	267
H	FORMEL	268
H	FORMEL	269
Br	FORMEL	270

### Preparation of heterocyclic fredericamycin derivatives

The fredericamycin aldehyde (4) can be reacted to pyridal acetone (271) according to Wittig or Wittig-Horner. Bromation with bromine in DMF yields the dibromo-derivative (272) substituted in the side chain and at the B ring. With the appropriately substituted thioamides or thioureas, the respective thiazole derivatives (273-276) are accessible.

Diagram 12

(FORMEL)

TMG: Tetramethylguanidine

Table 6

R	Example
NH <sub>2</sub>	273
Ph	274
CH <sub>3</sub> CONH	275
CH <sub>3</sub>	276

### Preparation of thioanalogues of fredericamycin derivatives

By sulfurization of fredericamycin or its derivatives with Lawesson reagent or P<sub>4</sub>S<sub>10</sub> in pyridine, the derivatives analogous to thiopyridone are accessible (see diagram 13).

Diagram 13

(FORMEL) -----> P<sub>4</sub>S<sub>10</sub> or Lawesson reagent pyridine-----> (FORMEL)

Fredericamycin (1) forms inclusion compounds such as (25) with polysugars such as  $\alpha$ -cyclodextrin, that have good water solubility compared to the original substance.

The dextrin inclusion compounds form easily if the components are mixed in the appropriate stoichiometric ratio in a suitable solvent such as DMSO (see diagram 11).

(FORMEL)

**Biological activity against 12 cancer cell lines:**

LCL (H460, lung), MACL (MCF7, breast), LXFL (52L, lung), LXFA (629L, lung), MEXF (462NL, melanoma), MEXF (514L, melanoma), MAXF (401NL, breast), RXF (944L, renal), RXF (486L, renal), UXF (1138L, uterus), PRXF (PC3M, prostate), PRXF (22RV1).

**Efficacy (IC70) averaged over all cell lines in  $\mu\text{g/mL}$  at 5 test concentrations**

Table 7

Example / reference	IC70 $\mu\text{g/mL}$
adriamycin	0.0210
cisplatin	37.1020
fredericamycin	0.2790
1	0.1130
13	0.0050
14	0.0070
22	0.0080
23	0.0110
121	0.2020
127	0.1550
192	0.0750
196	0.0950
197	0.0340
198	0.2560
203	0.1590
212	0.2100

214	0.0220
215	0.0720
217	0.1290
218	0.0760
224	0.0470
225	0.1110
230	0.0910
232	0.3170
233	0.1000
234	0.0520
235	0.0810
236	0.1210
265	0.1330
275	0.3680
276	0.0840

## Examples

### Example 1

**1-Desoxy-5-C-[(8R)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]pentitol (2)**

Two hundred (200) mg (0.38 mmol) fredericamycin A (1) are dissolved in 30 mL dichloromethane. After addition of 20 mL methanol and 4.4 ml water, 350 mg (2.6 mmol) N-methylmorpholine-N-oxide are added. Under vigorous stirring, 0.2 ml of a 2.5% osmium(IV)oxide solution in t-butanol is added dropwise. The reaction mixture is acidified with 2-3 drops of trifluoroacetic acid. After stirring for 48 hours, the reaction is complete according to HPLC control (RP18, acetonitrile water (0.2% acetic acid)). The reaction mixture is added to 400 ml water under vigorous stirring, and the dark red crystalline solid is sucked off through a filter. Drying in HV. Yield: 195 mg (87% of the theoretical value) dark red powder. ES<sup>-</sup>: M/e = 606.2 (M<sup>+</sup>-H), λ<sub>max</sub>: 504.0.

### Example 2

**Tri-potassium-1-desoxy-5-C-[(8R)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]pentitol (3)**

Twelve (12.0) mg (19.8  $\mu$ mol) fredericamycin tetrol (2) are dissolved in 1.5 mL absolute pyridine under nitrogen atmosphere. The solution is gassed for 30 min with argon at 0° C. Under the argon atmosphere, 5.94 mL of a 0.01 N KOH solution are added at once at 0° C. The reaction solution immediately turns turquoise. The reaction mixture is stirred for another 1 hour, and subsequently is frozen and lyophilized. Yield: 13.2 mg (100% of the theoretical value); deep blue crystal mass.

**Example 3**

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde (4)**

1.) Fifty (50) mg (82.3  $\mu$ mol) tetrahydroxy fredericamycin (tetrol (2)) are dissolved in 4 mL DMF. Under vigorous stirring, an aqueous sodium iodate solution (300 mg NaIO<sub>4</sub> in 1 mL water) is added dropwise within one hour. After 1 h stirring at room temperature, 2 drops of trifluoroacetic acid are added. After stirring for another 30 min, the reaction solution is diluted with 3 mL DMF, and 150 mg NaIO<sub>4</sub> dissolved in 0.5 mL water are added.

After another hour, 100 mL water are added. The supernatant over the precipitate is sucked off, and dried in HV. Dark red crystal powder. Yield: 41 mg (100 % of the theoretical value). M/e = 501:3, UV<sub>max</sub>: 504.0 nm.

2.) One hundred and nine (109) mg (179  $\mu$ mol) fredericamycin tetrol (2) are dissolved in 8 mL pyridine. 180  $\mu$ L water are added. To the reaction mixture, 450 mg (1.08 mmol, 6 eq.) (polystyrylmethyl)trimethylammonium periodate resin are added. Then the mixture is stirred for 12 h at RT. The resin is filtered off; washing and concentrating until dry. Dark red residue. Yield: 89.9 mg (100 % of the theoretical value). M/e = 501.3, UV<sub>max</sub>: 504.0 nm.

**Example 4**



**1-[2-Oxo-2-((2E)-2-[(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene}ethyl]-dimethylamino trifluoroacetate (118)**

Twenty (20) mg (39.9  $\mu\text{mol}$ ) fredericamycin aldehyde (4) are dissolved under argon in 1.5 mL absolute DMF. Addition of 9.1 mg (47.9  $\mu\text{mol}$ , 1.2 eq.) acetylhydrazide dimethylammoniumchloride (Girard reagent D) and 20 mg polyvinylpyridine (2% DVB). The mixture is stirred for 2.5 h. Then, 27 mg (80  $\mu\text{mol}$ , 2.0 eq.) aldehyde Wang resin (coating: 3.0 mmol/g) are added and stirred for another 1 h. Then, the resin is filtered, and washed 3x with DMF. Concentration in high vacuum. The residue is dissolved in 1 ml trifluoroacetic acid, and concentrated after 10 min until dry.

Red solid; Yield: 28.5 mg (100%);  $\text{ES}^+$ :  $\text{M/e} = 601.3$ ,  $\text{UV}_{\text{max}}$ : 504.0 nm.

#### Example 5

**1-[2-Oxo-2-((2E)-2-[(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene}hydrazino)-ethyl]pyridinium chloride (119)**

Fifteen (15) mg (29.9  $\mu\text{mol}$ ) fredericamycin aldehyde (4) are dissolved in 3 mL DMF. At room temperature 7.5 mg (40.0  $\mu\text{mol}$ ) acethydrazinopyridinium chloride (Girard reagent P) dissolved in 75  $\mu\text{L}$  water are added. The reaction mixture is stirred for 1.5 h at room temperature, and the course of the reaction is monitored by HPLC. When finished, acetic acid ethyl ester is added to the reaction mixture, until a precipitation occurs. After the crystallization is finished, the red solid is sucked off.

Yield: 9.1 mg (44% of the theoretical value).  $\text{M/e} = 635.2$ ;  $\lambda_{\text{max}}$ : 486.0.

#### Example 6

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde oxime (122)**

Ten (10) mg (19.4  $\mu\text{mol}$ ) fredericamycin aldehyde (4) are dissolved in 2 mL DMF. After addition of 3.1 mg (44.6  $\mu\text{mol}$ ) hydroxylammonium chloride, 3.2  $\mu\text{l}$  pyridine are added. Stirring for 2 h at room temperature. The reaction mixture is added to 50 ml water and extracted 3 times with ethyl acetate. After drying and concentration, a deep red amorphous crystal powder was left (HPLC clean).

Yield: 7.4 mg (72% of the theoretical value).  $\text{ES}^-$ :  $M/e = 516.1$ ;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 7

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-O-methyloxime (8)**

Ten (10) mg (19.4  $\mu\text{mol}$ ) fredericamycin aldehyde (4) are dissolved in 2 mL DMF. After addition of 3.4 mg (40.7  $\mu\text{mol}$ ) O-methylhydroxylammonium chloride and 3.2  $\mu\text{l}$  pyridine, the reaction mixture is stirred for 2 h at room temperature. Then, it is added to 100 ml water, and the supernatant is sucked off from the red precipitate (HPLC clean).

Yield: 7.6 mg (71% of the theoretical value).  $\text{ES}^+$ :  $M/e = 531.2$ ;  $\lambda_{\text{max}}$ : 500.0.

#### Example 8

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-O-benzyloxime (9)**

Ten (10) mg (19.4  $\mu\text{mol}$ ) fredericamycin aldehyde (4) are dissolved in 2 mL DMF. After addition of 6.4 mg (43.2  $\mu\text{mol}$ ) O-benzylhydroxylammonium chloride and 3.2  $\mu\text{l}$  pyridine, the reaction mixture is stirred for 2 h at room temperature. Then, it is added to 50 ml water, and the supernatant is sucked off from the red precipitate (HPLC clean).

Yield: 6.8 mg (57% of the theoretical value).  $\text{ES}^+$ :  $M/e = 607.2$ ;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 9

**1-O-(((1*E*)-[(8*S*)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene}amino)- $\beta$ -D-glucopyranose (10)**

Two (2.0) mg (4.0  $\mu$ mol) fredericamycin aldehyde (4) are dissolved in 150  $\mu$ L DMF, and 0.86 mg (4.4  $\mu$ mol)  $\beta$ -aminoxyl-D-glucopyranose is added. The mixture is stirred for 24 h at room temperature, and 5 mg (15.0  $\mu$ mol) aldehyde Wang resin (coating: 3.0 mmol/g) is added. After stirring for another 3 h, the resin is filtered off, washed with DMF, and the filtrate is concentrated in high vacuum until dry.

Yield: 2.7 mg (99% of the theoretical value). red powder; ES<sup>-</sup>: M/e = 678.1;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 10

**(8*S*)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-1,1',3',5',8'(2*H*)-pentone (11)**

Thirty (30) mg (49.4  $\mu$ mol) tetrahydroxy fredericamycin (2) were dissolved in 2 mL pyridine. Twenty (20) mg (93.0  $\mu$ mol) sodium metaperiodate dissolved in 0.3 ml water are added. After stirring for 4 h, 10 mg (260  $\mu$ mol) sodium borohydride are added. After 12 h, concentration until dry, and the residue is separated by preparative HPLC.

Yield: 2.6 mg (13% of the theoretical value) red powder. ES<sup>-</sup>: M/e = 503.2;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 11

**(8*S*)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carboxylic acid (12)**

Fifteen (15) mg (29.9  $\mu$ mol) fredericamycin aldehyde (4) are dissolved in 1 mL dichloromethane and 0.5 ml t-butanol. Addition of 250  $\mu$ l 2,4-dimethylbutene. Under stirring at room temperature, a solution of 6.0 mg (53.1  $\mu$ mol) sodium chlorite (80%) and 5.1 mg sodium hydrogenphosphate in 250  $\mu$ l water are added dropwise.

After 2.5 h, again a solution of 10.0 mg (88.5  $\mu\text{mol}$ ) sodium chlorite and 5 mg sodium dihydrogenphosphate in 200  $\mu\text{l}$  water are added. After altogether 4 h, it is put on water, and extracted with ethyl acetate.

The raw mixture was purified by preparative HPLC (RP18, acetonitrile-water-acetic acid). Red amorphous powder.

Yield: 68.3 mg (53.5% of the theoretical value).  $E^-$ :  $M/e = 516.1$ ;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 12

**Potassium(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carboxylate (13)**

6.9 mg (13.3  $\mu\text{mol}$ ) Fredericamycin carboxylic acid (12) are dissolved in 5 mL DMF under nitrogen. At room temperature and under oxygen exclusion and vigorous stirring, 1.27 mL (12.7  $\mu\text{mol}$ ) of an aqueous 0.01 N KOH solution is added dropwise. It is stirred for 15 minutes at room temperature, and concentrated in high vacuum until dry.

Yield: 7.40 mg (100% of the theoretical value).  $E^-$ :  $M/e = 516.1$ ;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 13

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (14)**

Twenty (20) mg (37.1  $\mu\text{mol}$ ) fredericamycin (1) were dissolved in 250  $\mu\text{l}$  DMF, and then 6.3 mg (35.3  $\mu\text{mol}$ ) N-bromosuccinimide in 250  $\mu\text{l}$  DMF were added within one hour at 0° C. The reaction was stirred in a slowly thawing ice bath over night. Then, the DMF is removed in high vacuum, and the residue is purified by preparative HPLC.

Yield: 7 mg (32% of the theoretical value) red crystal mass.  $M/e = 616.1/618.1$ ;  $\lambda_{\text{max}}$ : 486.0 nm.

#### Example 14

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (15)**

Eighty four (84) mg (158  $\mu$ mol) fredericamycin (1) were dissolved in 1.0  $\mu$ l DMF, and then 33.0 mg (150.0  $\mu$ mol) N-iodosuccinimide in 500  $\mu$ l DMF were added within one hour at 0° C. The reaction was stirred in a slowly thawing ice bath over night. Then, the DMF is removed in high vacuum, and the residue (120 mg (14) with a content of 80%) is purified by preparative HPLC (gradient CH<sub>3</sub>CN 50-90% over 16 min.)

Yield: 18 mg (17% of the theoretical value) red crystal mass. M/e = 665.0;  $\lambda_{\max}$ : 484.0 nm.

#### Example 15

**Methyl-2-(((benzyloxy)carbonyl)amino)-3-[(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]acrylate (23)**

Sixty six (66) mg (200  $\mu$ mol) Z- $\alpha$ -phosphonoglycine trimethylester are dissolved under argon in 1 mL absolute pyridine, and 25  $\mu$ L 1,1,3,3-tetramethylguanidine are added at 0° C. After 40 min. 20 mg (40  $\mu$ mol) fredericamycin aldehyde (4) is added at 0° C. After 15 min. 20 ml 1 M acetic acid is added, and the mixture is extracted 3 x with acetic acid. The raw product is purified by preparative HPLC (RP18, acetonitrile-water).

Yield: 10.0 mg (36% of the theoretical value). M/e = 706.4;  $\lambda_{\max}$ : 492.0 nm.

#### Example 16

**(8S)-9-hydroxy-4',6',9'-trimethoxy-2-methyl-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (24)**

Ten (10) mg (15  $\mu$ mol) fredericamycin (1) were dissolved under protective gas in 4 ml absolute DMF. At RT, 400  $\mu$ l (4311  $\mu$ mol) methyl iodide and 81 mg powdered potassium carbonate are added. The reactions mixture is then stirred at RT for 20 h, and is then

transferred onto water. Extraction with ethyl acetate, and purification of the residue by separating chromatography on chloroform/methanol 30/1.

Yield: 4 mg (37% of the theoretical value). Yellow residue.  $M/e = 582.3$ ;  $\lambda_{\max}$ : 368.0 nm.

### Example 17

#### Fredericamycin A 1:2 complex with $\alpha$ -cyclodextrin (22)

Ten (10) mg fredericamycin (0.025 mMol) are added to a solution of 50 mg  $\alpha$ -cyclodextrin (0.050 mMol) in 500  $\mu$ l dimethylsulfoxide. The solution is then diluted with 5 ml water. A stock solution prepared in such way can be diluted as desired with water.

$\lambda_{\max} = 504.0$  nm.

### Example 18

#### 4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde(4-methylpiperazine-1-yl)hydrazone (111)

Five (5) mg (9.42  $\mu$ mol) fredericamycin aldehyde (4) are dissolved in 500  $\mu$ l DMF and 25  $\mu$ l trifluoroacetic acid. At room temperature, 1.30 mg (11.3  $\mu$ mol) 1-amino-4-methyl-piperazine is added. After stirring for 4.5 h at room temperature, 1 equivalent each of Wang aldehyde resin and sulfonohydrazide resin is added and stirred for 2 h.

Filtration and concentration of the reaction solution at high vacuum.

Red powder. Yield: 5.4 mg (91% of the theoretical value).  $M/e = 599$  ( $M+H$ )<sup>+</sup>;  $\lambda_{\max}$ : 504.0 nm.

### Example 19

#### 4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-4,5-dihydro-1*H*-imidazole-2-yl-hydrazone (123)

Five (5.00) mg (9.42  $\mu$ mol) fredericamycin aldehyde (4) are dissolved in 500  $\mu$ l DMF and 25  $\mu$ l trifluoroacetic acid. At room temperature, 2.05 mg (11.3  $\mu$ mol) 2-hydrazino-2-imidazolin hydrobromide is added. After stirring for 4.5 h at room temperature, 1 equivalent each of Wang aldehyde resin and sulfonohydrazide resin are added and stirred for 2 h. Separation of the resin by filtration and concentration of the reaction solution at high vacuum.

Red powder. Yield: 3.9 mg (67% of the theoretical value).  $M/e = 584 (M+H)^+$ ;  $\lambda_{\max}$ : 504.0 nm.

#### Example 20

**4',9,9'-Trihydroxy-6'-methoxy-3- $\{ (E)-[(4\text{-oxo-2-thioxo-1,3-thiazolidin-3-yl)imino]methyl\}$ -6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2*H*)-pentone (123)**

Five (5.00) mg (9.42  $\mu$ mol) fredericamycin aldehyde (4) are dissolved in 500  $\mu$ l DMF and 25  $\mu$ l trifluoroacetic acid. At room temperature, 1.67 mg (11.3  $\mu$ mol) 2N-aminorhodanide are added. After stirring for 4.5 h at room temperature, 1 equivalent each of Wang aldehyde resin and sulfonohydrazide resin are added and stirred for 2 h.

Filtration and concentration of the reaction solution.

Red powder. Yield: 4.1 mg (65% of the theoretical value).  $M/e = 599 (M+H)^+$ ;  $\lambda_{\max}$ : 504.0 nm.

#### Example 21

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-*O*-(2-morpholine-4-ylethyl)oxime (27)**

Five (5.00) mg (9.42  $\mu$ mol) fredericamycin aldehyde (4) are dissolved in 500  $\mu$ l DMF and 25  $\mu$ l trifluoroacetic acid. At room temperature, 2.47 mg (11.3  $\mu$ mol) N-(aminoxyethyl)morpholine dihydrochloride is added. After stirring for 4.5 h at room temperature, 1 equivalent of Wang aldehyde resin (3.1 mg, 9.4  $\mu$ mol, coating: 3.0 mmol/g) as well as 1 equivalent sulfonohydrazide resin (6.1 mg, 9.4 mmol, 1.5 mmol) are added and stirred for 2 h.

Filtration and concentration of the reaction solution.

Red powder. Yield: 6.1 mg (98% of the theoretical value).  $M/e = 630$  ( $M+H$ )<sup>+</sup>;  $\lambda_{\max}$ : 504.0 nm.

#### Example 22

**(8S)-5-chloro-4',6',9'-trimethoxy-2-methoxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (34)**

Three hundred (300) mg (556.6  $\mu$ mol) fredericamycin (1) are dissolved under argon in 10  $\mu$ l DMF, and then 75.0 mg (556.6  $\mu$ mol) N-chlorosuccinimide are added. The reaction is stirred for 5 h at 40° C. The reaction mixture is then added to 400 ml methanol/water 1:1, and the red precipitate is sucked off and dried at high vacuum.

Yield: 305 mg (96% of the theoretical value) red crystal mass.  $M/e = 573/575$ ;  $\lambda_{\max}$ : 504.0 nm.

#### Example 23

**(8S)-5-fluoro-4',9,9'-trihydroxy-6'-methoxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (35)**

Fifty (50) mg (92.8  $\mu$ mol) fredericamycin (1) are dissolved in 5 ml DMF under argon, and then 33.0 mg (93.5  $\mu$ mol) 1-chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis(tetrafluoroborate) Selectfluor® is added. The reaction is stirred for 24 h at room temperature. The reaction mixture is then added to 200 ml water, and is extracted with ethyl acetate. The concentrated raw product is purified by preparative HPLC (RP18, acetonitrile-water-acetic acid).

Yield: 7.1 mg (14% of the theoretical value) red crystal mass.  $M/e = 557$ ;  $\lambda_{\max}$ : 504.0 nm.

#### Example 24



**1-Desoxy-5-C-[(8R)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]-pentitol (36)**

Hundred twenty (120) mg (209  $\mu$ mol) chlorofredericamycin (34) are dissolved in 25.0 ml dichloromethane. After addition of 3.6 ml methanol and 0.8 ml water, 197 mg (1.46 mmol) N-methylmorpholine-N-oxide is added. Under vigorous stirring, 0.12 ml of a 2.5% solution of osmium(IV)oxide in t-butanol is added dropwise. After stirring for 27 hours, the reaction is complete, according to HPLC monitoring (RP18, acetonitrile-water (0.2% acetic acid)). The reaction mixture is added to 200 ml water under vigorous stirring, and the dark red solid is sucked off. Drying in HV.

Yield: 101 mg (75% of the theoretical value) dark red powder.  $M/e = 641/643$ ;  $\lambda_{\max}$ : 504.0.

**Example 25**

**(8S)-4',9,9'-trihydroxy-5-bromo-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde (37)**

Hundred (100) mg (200  $\mu$ mol) fredericamycin aldehyde (4) are dissolved under argon in 5 ml DMF. Then, 200  $\mu$ l of a 1M bromine solution in DMF is added. After stirring for 1.5 h at RT, another 20  $\mu$ l bromine solution are added. According to HPLC monitoring, the reaction mixture is complete after 3.5 h.

Add to 150 ml water, and shake out with dichloromethane.

Yield: 96 mg (83% of the theoretical value) dark red powder.  $M/e = 579/581$ ;  $\lambda_{\max}$ : 504.0.

**Example 26**

**1,2,3,4-Tetrahydro-5-bromo-4',9,9'-trihydroxy-6'-methoxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (26)**

Eight (8.0) mg (0.0128 mmol) 1,2,3,4-tetrahydrofredericamycin (25) are dissolved in 1 ml absolute DMF under nitrogen. Then a solution of 2.3 mg (0.0128 mmol) bromine in 0.25 ml

DMF is added dropwise to the solution. Stirring at room temperature over 24 h. The reaction mixture is concentrated to half volume in high vacuum, and is then transferred onto 100 ml water. The supernatant is sucked off from the precipitate and dried in a vacuum.

Red crystal powder 8.1 mg (88% of the theoretical value)  $m/e = 621/623$ ;  $\lambda_{\max}$ : 499 nm.

#### Example 27

**(8S)-4',9,9'-trihydroxy-6'-benzylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone**

Twenty (20) mg (37.1  $\mu\text{mol}$ ) fredericamycin are dissolved in 1 ml DMF under argon, then 4.76 mg (44.50  $\mu\text{mol}$ ) benzylamine are added at room temperature. According to HPLC (RP18, acetonitrile/water), a homogenous new product has formed after 3 h. The reaction mixture is concentrated at high vacuum until dry.

Red crystal mass; Yield: 23 mg (100% of the theoretical value)  $M/e = 615.3$  ( $M+H$ );  $\lambda_{\max}$ : 492 nm.

#### Example 28

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-benzylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone**

Five (5.0) mg (8.71  $\mu\text{mol}$ ) 5-chlorofredericamycin are dissolved in 1 ml DMF under argon, then 1.12 mg (10.45  $\mu\text{mol}$ ) benzylamine are added at room temperature. After 29 h, the reaction mixture is concentrated at high vacuum until dry.

Red crystal mass; Yield: 5 mg (89% of the theoretical value)  $M/e = 649.1$  ( $M+H$ );  $\lambda_{\max}$ : 492 nm.

#### Example 28 (Translator: 28a)

**(8S)-4',9,9'-trihydroxy-6'-ethanolamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone**

Ten (10) mg (18.6  $\mu\text{mol}$ ) fredericamycin are dissolved in 1 ml DMF under argon, then 1.36 mg (22.3  $\mu\text{mol}$ ) ethanolamine are added at room temperature. According to HPLC (RP18, acetonitrile/water), a homogenous new product has formed after 3 h. The reaction mixture is concentrated at high vacuum until dry.

Red crystal mass; Yield: 9 mg (85% of the theoretical value)  $M/e = 569.3$  ( $M+H$ );  $\lambda_{\text{max}}$ : 500 nm.

#### Example 29

**(8S)-4',9,9'-trihydroxy-6'-(4-piperidylmethylamino)-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone**

Ten (10) mg (18.6  $\mu\text{mol}$ ) fredericamycin are dissolved in 1 ml DMF under argon, then 2.7  $\mu\text{l}$  (22.3  $\mu\text{mol}$ ) 4-aminomethylpiperidine are added at room temperature. The reaction mixture is concentrated at high vacuum until dry after 24 h.

Red crystal mass; Yield: 11 mg (99% of the theoretical value)  $M/e = 622.3$  ( $M+H$ );  $\lambda_{\text{max}}$ : 492 nm.

#### Examples 100 – 142

The compounds 100 – 142 can be generated analogously to examples 7, 8, 9, 10, 18, 19 and 20:

#### Example 100

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydepiperidine-2-yl-hydrazone (100)**

Yield: (95% of the theoretical value) MS:  $M/e = 593.1$ ;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 101**

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde [4-(trifluoromethyl)pyrimidine-2-yl]hydrazone (101)**

Yield: (95% of the theoretical value) MS: M/e = 562.1;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 102**

**N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]pyridyl-3-carbohydrazine (102)**

Yield: (95% of the theoretical value) MS: M/e = 621.1;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 103**

**N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]isonicotinohydrazine (103)**

Yield: (95% of the theoretical value) MS: M/e = 621.1;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 104**

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-1,2,4-triazole-4-ylhydrazone (104)**

Yield: (80% of the theoretical value) MS: M/e = 568.1;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 105**

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-4,5-dihydro-1H-imidazole-2-ylhydrazone (105)**

Yield: (95% of the theoretical value) MS: M/e = 584.1;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 106**

**N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]-2-furohydrazine (106)**

Yield: (95% of the theoretical value) MS:  $M/e = 610.0$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 107

**4-Amino-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]benzohydrazine (107)**

Yield: (95% of the theoretical value) MS:  $M/e = 635.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 108

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydethiosemicarbazone (108)**

Yield: (95% of the theoretical value) MS:  $M/e = 558.0$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 109

**N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]thiophene-2-carbohydrazine (109)**

Yield: (95% of the theoretical value) MS:  $M/e = 626.0$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 110

**2-(1*H*-indole-3-yl)-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazine (110)**

Yield: (95% of the theoretical value) MS:  $M/e = 673.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 111

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde(4-methylpiperazine-1-yl)hydrazone (111)**

Yield: (95% of the theoretical value) MS:  $M/e = 599.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 112

**2-Oxo-2-[(2E)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]-hydrazino}acetamide (112)**

Yield: (95% of the theoretical value) MS:  $M/e = 587.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 113

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (113)**

Yield: (95% of the theoretical value) MS:  $M/e = 632.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 114

**{(2E)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]-hydrazino}acetonitrile (114)**

Yield: (95% of the theoretical value) MS:  $M/e = 583.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 115

**2-Amino-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]benzohydrazine (115)**

Yield: (95% of the theoretical value) MS:  $M/e = 635.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 116

**4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde O-[2-morpholine-4-yl-ethyl]oxime (116)**

Yield: (85% of the theoretical value) MS:  $M/e = 630.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 117

**(2E)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazinecarboximidamide (117)**

Yield: (95% of the theoretical value) MS:  $M/e = 558.1$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 118**

**2-(Dimethylamino)-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazine (118)**

Yield: (85% of the theoretical value) MS: M/e = 601.1;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 119**

**1-[2-Oxo-2-((2E)-2-[(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene}hydrazino)ethyl]pyridinium chloride (119)**

Yield: (85% of the theoretical value) MS: M/e = 635.1;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 120**

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-methyloxime (120)**

Yield: (90% of the theoretical value) MS: M/e = 531.1;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 121**

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-benzyloxime (121)**

Yield: (95% of the theoretical value) MS: M/e = 607.1;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 122**

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde oxime (122)**

Yield: (95% of the theoretical value) MS: M/e = 517.1;  $\lambda_{\text{max}}$ : 482.0 nm.

**Example 123**

**1-O-(((1E)-[(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene}amino)- $\beta$ -D-glucopyranose (123)**

Yield: (95% of the theoretical value) MS:  $M/e = 679.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 124

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-phenylsemicarbazone (124)**

Yield: (95% of the theoretical value) MS:  $M/e = 635.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 125

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydesemicarbazone (125)**

Yield: (95% of the theoretical value) MS:  $M/e = 559.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 126

**2-Piperidino-4-yl-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (126)**

Yield: (95% of the theoretical value) MS:  $M/e = 641.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 127

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(3-chlorobenzyl)oxime (127)**

Yield: (95% of the theoretical value) MS:  $M/e = 641.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 128

**N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]-(2-methyl-1,3-thiazole-4yl)carbohydrazide (128)**

Yield: (95% of the theoretical value) MS:  $M/e = 641.1$ ;  $\lambda_{\max}$ : 492.0 nm.



**Example 129**

**2-(1*H*-imidazole-1-yl)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (129)**

Yield: (90% of the theoretical value) MS:  $M/e = 624.1$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 130**

**2-(Acetylamino)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (130)**

Yield: (95% of the theoretical value) MS:  $M/e = 615.1$ ;  $\lambda_{\max}$ : 492.0 nm.

**Example 131**

**2-(4-Methylpiperazine-1-yl)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (131)**

Yield: (50% of the theoretical value) MS:  $M/e = 656.1$ ;  $\lambda_{\max}$ : 492.0 nm.

**Example 132**

**2-Morpholine-4-yl-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (132)**

Yield: (60% of the theoretical value) MS:  $M/e = 643.1$ ;  $\lambda_{\max}$ : 492.0 nm.

**Example 133**

**2-(Methylamino)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (133)**

Yield: (70% of the theoretical value) MS:  $M/e = 587.1$ ;  $\lambda_{\max}$ : 492.0 nm.

**Example 134**

**2-[Isopropyl(methyl)amino]-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (134)**

Yield: (70% of the theoretical value) MS:  $M/e = 629.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 135

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-[2-(dimethylamino)ethyl]oxime (127)**

Yield: (90% of the theoretical value) MS:  $M/e = 588.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 136

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-[3-(4-(3-chlorophenyl)-piperazine-1-yl)propyl]oxime (136)**

Yield: (85% of the theoretical value) MS:  $M/e = 753.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 137

**4',9,9'-Trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-[3-(dimethylamino)propyl]oxime (137)**

Yield: (70% of the theoretical value) MS:  $M/e = 602.1$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 138

**(8*S*)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde pyridine-2-yl-hydrazone (138)**

Yield: (95% of the theoretical value) MS:  $M/e = 627.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 139

**(8*S*)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde [4-(trifluoromethyl)pyrimidine-2-yl]hydrazone (139)**

Yield: (95% of the theoretical value) MS:  $M/e = 696.0$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 140**

**(8S)-5-chloro-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]pyridyl-3-carbohydrazine (140)**

Yield: (95% of the theoretical value) MS: M/e = 655.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 141**

**(8S)-5-chloro-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]isonicotinohydrazide (141)**

Yield: (95% of the theoretical value) MS: M/e = 655.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 142**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-1,2,4-triazole-4-ylhydrazone (142)**

Yield: (90% of the theoretical value) MS: M/e = 602.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 143**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-4,5-dihydro-1H-imidazole-2-ylhydrazone (143)**

Yield: (95% of the theoretical value) MS: M/e = 618.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 144**

**(8S)-5-chloro-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]-2-furohydrazide (144)**

Yield: (95% of the theoretical value) MS: M/e = 644.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 145**

**(8S)-5-chloro-4-amino-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]-benzohydrazide (145)**

Yield: (95% of the theoretical value) MS: M/e = 669.0;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 146

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydethiosemicarbazone (146)**

Yield: (95% of the theoretical value) MS: M/e = 609.0;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 147

**(8S)-5-chloro-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]thiophene-2-carbohydrazide (147)**

Yield: (95% of the theoretical value) MS: M/e = 660.0;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 148

**(8S)-5-chloro-2-(1*H*-indole-3-yl)-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (148)**

Yield: (95% of the theoretical value) MS: M/e = 707.1;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 149

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde(4-methylpiperazine-1-yl)hydrazone (149)**

Yield: (95% of the theoretical value) MS: M/e = 633.1;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 150

**(8S)-5-chloro-2-oxo-2-[(2*E*)-2-[4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazino}acetamide (150)**

Yield: (95% of the theoretical value) MS: M/e = 621.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 151**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (151)**

Yield: (95% of the theoretical value) MS: M/e = 665.3;  $\lambda_{\max}$ : 500.0 nm.

**Example 152**

**(8S)-5-chloro-[(2E)-2-[4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazino]acetonitrile (152)**

Yield: (95% of the theoretical value) MS: M/e = 617.1;  $\lambda_{\max}$ : 500.0 nm.

**Example 153**

**(8S)-5-chloro-2-amino-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]benzohydrazide (153)**

Yield: (95% of the theoretical value) MS: M/e = 669.1;  $\lambda_{\max}$ : 500.0 nm.

**Example 154**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde O-[2-morpholine-4-yl-ethyl]oxime (154)**

Yield: (95% of the theoretical value) MS: M/e = 664.1;  $\lambda_{\max}$ : 500.0 nm.

**Example 155**

**(8S)-5-chloro-(2E)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazinecarboximidamide (155)**

Yield: (95% of the theoretical value) MS: M/e = 592.1;  $\lambda_{\max}$ : 500.0 nm.

**Example 156**

**(8S)-5-chloro-2-(dimethylamino)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (156)**

Yield: (95% of the theoretical value) MS:  $M/e = 635.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 157

**(8S)-5-chloro-1-[2-oxo-2-((2*E*)-2-[(8S)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]hydrazino)ethyl]pyridinium chloride (157)**

Yield: (95% of the theoretical value) MS:  $M/e = 669.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 158

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde-*O*-methyloxime (158)**

Yield: (95% of the theoretical value) MS:  $M/e = 565.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 159

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde-*O*-benzyloxime (159)**

Yield: (95% of the theoretical value) MS:  $M/e = 641.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 160

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde oxime (160)**

Yield: (95% of the theoretical value) MS:  $M/e = 551.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 161

**(8S)-5-chloro-1-O-((1*E*)-[(8S)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]amino)- $\beta$ -D-glucopyranose (161)**

Yield: (95% of the theoretical value) MS:  $M/e = 713.1$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 162**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-phenylsemicarbazone (162)**

Yield: (95% of the theoretical value) MS: M/e = 669.1;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 163**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydesemicarbazone (163)**

Yield: (90% of the theoretical value) MS: M/e = 593.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 164**

**(8S)-5-chloro-2-piperidino-4-yl-N'-[(1E)-[(8S)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (164)**

Yield: (95% of the theoretical value) MS: M/e = 675.1;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 165**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(3-chlorobenzyl)oxime (165)**

Yield: (90% of the theoretical value) MS: M/e = 675.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 166**

**(8S)-5-chloro-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]a-2-methyl-1,3-thiazole-4-yl-carbohydrazide (166)**

Yield: (95% of the theoretical value) MS: M/e = 675.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 167**

**(8S)-5-chloro-2-(1*H*-imidazole-1-yl)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaaxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (1647)**

Yield: (90% of the theoretical value) MS:  $M/e = 658.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 168

**(8S)-5-chloro-2-(acetylamino)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaaxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (164)**

Yield: (95% of the theoretical value) MS:  $M/e = 649.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 169

**(8S)-5-chloro-2-(4-methylpiperazine-1-yl)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaaxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (169)**

Yield: (60% of the theoretical value) MS:  $M/e = 690.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 170

**(8S)-5-chloro-2-morpholine-4-yl-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaaxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (170)**

Yield: (60% of the theoretical value) MS:  $M/e = 677.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 171

**(8S)-5-chloro-2-(methylamino)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaaxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (171)**

Yield: (70% of the theoretical value) MS:  $M/e = 621.1$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 172

**(8S)-5-chloro-2-[isopropyl(methyl)amino]-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaaxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (172)**

Yield: (95% of the theoretical value) MS:  $M/e = 675.1$ ;  $\lambda_{\max}$ : 500.0 nm.



**Example 173**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[2-(dimethylamino)ethyl]-oxime (173)**

Yield: (60% of the theoretical value) MS:  $M/e = 622.0$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 174**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[3-(4-(3-chlorophenyl)-piperazine-1-yl)propyl]-oxime (174)**

Yield: (90% of the theoretical value) MS:  $M/e = 787.1$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 175**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[3-(dimethylamino)propyl]oxime (175)**

Yield: (75% of the theoretical value) MS:  $M/e = 636.1$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 176**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydepyridine-2-yl-hydrazone (176)**

Yield: (95% of the theoretical value) MS:  $M/e = 670.9$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 177**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde [4-(trifluoromethyl)pyrimidine-2-yl]hydrazone (177)**

Yield: (95% of the theoretical value) MS:  $M/e = 739.9$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 178**

**(8S)-5-bromo-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]pyridyl-3-carbohydrazide (178)**

Yield: (90% of the theoretical value) MS:  $M/e = 699.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 179

**(8S)-5-bromo-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]isonicotinohydrazide (179)**

Yield: (90% of the theoretical value) MS:  $M/e = 699.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 180

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde-1,2,4-triazole-4-ylhydrazone (180)**

Yield: (70% of the theoretical value) MS:  $M/e = 645.9$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 181

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde-4,5-dihydro-1*H*-imidazole-2-ylhydrazone (181)**

Yield: (95% of the theoretical value) MS:  $M/e = 662.0$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 182

**(8S)-5-bromo-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]-2-furohydrazide (182)**

Yield: (95% of the theoretical value) MS:  $M/e = 688.9$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 183

**(8S)-5-bromo-4-amino-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]benzohydrazide (183)**

Yield: (95% of the theoretical value) MS:  $M/e = 713.0$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 184**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydethiosemicarbazone (184)**

Yield: (95% of the theoretical value) MS: M/e = 653.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 185**

**(8S)-5-bromo-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]thiophene-2-carbohydrazide (185)**

Yield: (95% of the theoretical value) MS: M/e = 704.0;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 186**

**(8S)-5-bromo-2-(1*H*-indole-3-yl)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (186)**

Yield: (95% of the theoretical value) MS: M/e = 751.1;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 187**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde(4-methylpiperazine-1-yl)hydrazone (187)**

Yield: (95% of the theoretical value) MS: M/e = 677.1;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 188**

**(8S)-5-bromo-2-oxo-2-[(2*E*)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazino}acetamide (188)**

Yield: (95% of the theoretical value) MS: M/e = 665.0;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 189**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1',3',5',8'(2H)-pentone (189)**

Yield: (95% of the theoretical value) MS: M/e = 709.9;  $\lambda_{\max}$ : 492.0 nm.

#### Example 190

**(8S)-5-bromo-{(2E)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazino}acetonitrile (190)**

Yield: (95% of the theoretical value) MS: M/e = 661.0;  $\lambda_{\max}$ : 500.0 nm.

#### Example 191

**(8S)-5-bromo-2-amino-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]benzohydrazide (191)**

Yield: (70% of the theoretical value) MS: M/e = 713.0;  $\lambda_{\max}$ : 492.0 nm.

#### Example 192

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde O-[2-morpholine-4-yl-ethyl]oxime (192)**

Yield: (95% of the theoretical value) MS: M/e = 708.0;  $\lambda_{\max}$ : 500.0 nm.

#### Example 193

**(8S)-5-bromo-(2E)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazinecarboximidamide (193)**

Yield: (95% of the theoretical value) MS: M/e = 636.0;  $\lambda_{\max}$ : 500.0 nm.

#### Example 194

**(8S)-5-bromo-2-(dimethylamino)-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (194)**

Yield: (95% of the theoretical value) MS: M/e = 679.0;  $\lambda_{\max}$ : 500.0 nm.

**Example 195**

**(8S)-5-bromo-1-[2-oxo-2-((2E)-2-{[(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene}hydrazino)ethyl]pyridinium chloride (195)**

Yield: (95% of the theoretical value) MS: M/e = 713.0;  $\lambda_{\max}$ : 500.0 nm.

**Example 196**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-methyloxime (196)**

Yield: (95% of the theoretical value) MS: M/e = 609.0;  $\lambda_{\max}$ : 492.0 nm.

**Example 197**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-*O*-benzyloxime (197)**

Yield: (95% of the theoretical value) MS: M/e = 685.0;  $\lambda_{\max}$ : 492.0 nm.

**Example 198**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde oxime (198)**

Yield: (95% of the theoretical value) MS: M/e = 595.0;  $\lambda_{\max}$ : 492.0 nm.

**Example 199**

**(8S)-5-bromo-1-O-((1E)-[(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene)amino)- $\beta$ -D-glucopyranose (199)**

Yield: (90% of the theoretical value) MS: M/e = 757.0;  $\lambda_{\max}$ : 500.0 nm.

**Example 200**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde-phenylsemicarbazone (200)**

Yield: (90% of the theoretical value) MS:  $M/e = 713.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 201

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehydesemicarbazone (201)**

Yield: (90% of the theoretical value) MS:  $M/e = 637.0$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 202

**(8S)-5-bromo-2-piperidino-4-yl-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (201)**

Yield: (90% of the theoretical value) MS:  $M/e = 719.0$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 203

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(3-chlorobenzyl)oxime (203)**

Yield: (95% of the theoretical value) MS:  $M/e = 718.0$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 204

**(8S)-5-bromo-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]-2-methyl-1,3-thiazole-4-yl-carbohydrazide (204)**

Yield: (95% of the theoretical value) MS:  $M/e = 718.9$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 205

**(8S)-5-bromo-2-(1*H*-imidazole-1-yl)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (205)**

Yield: (95% of the theoretical value) MS:  $M/e = 702.0$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 206**

**(8S)-5-bromo-2-(acetylamino)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (206)**

Yield: (95% of the theoretical value) MS:  $M/e = 693.0$ ;  $\lambda_{\max}$ : 492.0 nm.

**Example 207**

**(8S)-5-bromo-2-(4-methylpiperazine-1-yl)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (207)**

Yield: (90% of the theoretical value) MS:  $M/e = 734.1$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 208**

**(8S)-5-bromo-2-morpholine-4-yl-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (208)**

Yield: (95% of the theoretical value) MS:  $M/e = 721.1$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 209**

**(8S)-5-bromo-2-(methylamino)-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (209)**

Yield: (95% of the theoretical value) MS:  $M/e = 665.0$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 210**

**(8S)-5-bromo-2-[isopropyl(methyl)amino]-*N'*-[(1*E*)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-yl)methylene]acetohydrazide (210)**

Yield: (95% of the theoretical value) MS:  $M/e = 707.0$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 211**

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[2-(dimethylamino)ethyl]oxime (211)**

Yield: (95% of the theoretical value) MS:  $M/e = 666.0$ ;  $\lambda_{\max}: 500.0 \text{ nm}$ .

#### Example 212

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[3-(4-(3-chlorophenyl)-piperazine-1-yl)propyl]oxime (212)**

Yield: (95% of the theoretical value) MS:  $M/e = 831.0$ ;  $\lambda_{\max}: 500.0 \text{ nm}$ .

#### Example 213

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[3-(dimethylamino)propyl]oxime (213)**

Yield: (95% of the theoretical value) MS:  $M/e = 680.0$ ;  $\lambda_{\max}: 492.0 \text{ nm}$ .

#### Example 214

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-isopropylloxime (214)**

Yield: (95% of the theoretical value) MS:  $M/e = 559.2$ ;  $\lambda_{\max}: 500.0 \text{ nm}$ .

#### Example 215

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-n-hexylloxime (215)**

Yield: (99% of the theoretical value) MS:  $M/e = 601.3$ ;  $\lambda_{\max}: 500.0 \text{ nm}$ .

#### Example 216

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(4-fluorobenzyl)oxime (216)**

Yield: (99% of the theoretical value) MS:  $M/e = 625.2$ ;  $\lambda_{\max}: 500.0 \text{ nm}$ .



**Example 217**

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(4-chlorobenzyl)oxime (217)**

Yield: (99% of the theoretical value) MS:  $M/e = 641.2$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 218**

**(8S)-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(3-fluorobenzyl)oxime (218)**

Yield: (99% of the theoretical value) MS:  $M/e = 625.3$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 219**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-isopropylloxime (219)**

Yield: (80% of the theoretical value) MS:  $M/e = 593.2$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 220**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-n-hexylloxime (220)**

Yield: (90% of the theoretical value) MS:  $M/e = 635.3$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 221**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(4-fluorobenzyl)oxime (221)**

Yield: (85% of the theoretical value) MS:  $M/e = 659.3$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 222**

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(4-chlorobenzyl)oxime (222)**

Yield: (80% of the theoretical value) MS:  $M/e = 675.3$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 223

**(8S)-5-chloro-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(3-fluorobenzyl)oxime (223)**

Yield: (80% of the theoretical value) MS:  $M/e = 659.3$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 224

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-isopropylloxime (224)**

Yield: (90% of the theoretical value) MS:  $M/e = 639.3$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 225

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-n-hexylloxime (225)**

Yield: (95% of the theoretical value) MS:  $M/e = 679.3$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 226

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(4-fluorobenzyl)oxime (226)**

Yield: (95% of the theoretical value) MS:  $M/e = 703.3$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 227

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoso-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(4-chlorobenzyl)oxime (227)**

Yield: (95% of the theoretical value) MS:  $M/e = 719.3$ ;  $\lambda_{\max}$ : 492.0 nm.

**Example 228**

(8S)-5-bromo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-(3-fluorobenzyl)oxime (228)

Yield: (95% of the theoretical value) MS:  $M/e = 705.3$ ;  $\lambda_{\max}$ : 492.0 nm.

**Example 229**

(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-isopropylloxime (229)

Yield: (99% of the theoretical value) MS:  $M/e = 685.3$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 230**

(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-*n*-hexylloxime (230)

Yield: (99% of the theoretical value) MS:  $M/e = 727.4$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 231**

(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-(4-fluorobenzyl)oxime (231)

Yield: (99% of the theoretical value) MS:  $M/e = 751.3$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 232**

(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-3-carbaldehyde *O*-(4-chlorobenzyl)oxime (232)

Yield: (99% of the theoretical value) MS:  $M/e = 767.3$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 233**

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(3-fluorobenzyl)oxime (233)**

Yield: (99% of the theoretical value) MS:  $M/e = 751.3$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 234

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-benzyloxime (234)**

Yield: (99% of the theoretical value) MS:  $M/e = 733.3$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 235

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[2-morpholine-4-yl-ethyl)oxime (235)**

Yield: (99% of the theoretical value) MS:  $M/e = 756.3$ ;  $\lambda_{\max}$ : 500.0 nm.

#### Example 236

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-methyloxime (236)**

Yield: (95% of the theoretical value) MS:  $M/e = 657.3$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 237

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-(3-chlorobenzyl)oxime (237)**

Yield: (99% of the theoretical value) MS:  $M/e = 767.3$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 238

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-pentaoxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde *O*-[3-(4-(3-chlorophenyl)-piperazine-1-yl)propyl]oxime (238)**

Yield: (99% of the theoretical value) MS:  $M/e = 879.4$ ;  $\lambda_{\max}$ : 500.0 nm.

**Example 239**

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-carbaldehyde oxime (239)**

Yield: (99% of the theoretical value) MS: M/e = 643.3;  $\lambda_{\max}$ : 492.0 nm.

**Example 240**

**(8S)-5-iodo-2-(4-methylpiperazine-1-yl)-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (240)**

Yield: (99% of the theoretical value) MS: M/e = 782.3;  $\lambda_{\max}$ : 500.0 nm.

**Example 241**

**(8S)-5-iodo-2-morpholine-4-yl-N'-[(1E)-(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]acetohydrazide (241)**

Yield: (99% of the theoretical value) MS: M/e = 782.3;  $\lambda_{\max}$ : 500.0 nm.

**Example 242**

**(8S)-5-iodo-2-oxo-2-[(2E)-2-[(4',9,9'-trihydroxy-6'-methoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl)methylene]hydrazino}acetamide (242)**

Yield: (99% of the theoretical value) MS: M/e = 713.3;  $\lambda_{\max}$ : 500.0 nm.

**Example 243**

**(8S)-4',9,9'-trihydroxy-6'-ethoxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (243)**

Five (5) mg (0.0095 mmol) fredericamycin (1) are suspended in 2.0 ml ethanol. Under N<sub>2</sub> atmosphere, 90 mg sodium acetate are added and boiled under reflux. After a few minutes, the suspension turns into a deep blue solution. After 24 h it is cooled, transferred onto water and shaken out with ethyl acetate (0.1% CF<sub>3</sub>COOH). After drying and concentration, a chromatographically homogenous, red powder is left.

Yield: 5.0 mg (97% of the theoretical value) MS = 554 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 244

**(8S)-4',9,9'-trihydroxy-6'-n-butoxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (244)**

Six (6) mg (0.0114 mmol) fredericamycin (1) are suspended in 3.0 ml n-butanol. Under N<sub>2</sub> atmosphere, 50 mg potassium acetate are added and heated to 100° C. After a few minutes, the suspension turns into a deep blue solution. The solution is left for 1 h at this temperature, and is then cooled. It is transferred onto water and shaken out with ethyl acetate (0.1% CF<sub>3</sub>COOH). After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 6.2 mg (96% of the theoretical value) MS = 582 (M)<sup>+</sup>;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 245

**(8S)-4',9,9'-trihydroxy-6'-n-isopropoxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (245)**

Five (5) mg (0.0095 mmol) fredericamycin (1) are suspended in 3.0 ml n-propanol. Under N<sub>2</sub> atmosphere, 50 mg potassium acetate (anhydrous) are added and heated to 80° C. After a few minutes, the suspension turns into a deep blue solution. The solution is left for 48 h at this temperature, and is then cooled. It is transferred onto water and shaken out with ethyl acetate (0.1% CF<sub>3</sub>COOH). After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 3.7 mg (70% of the theoretical value) MS = 568 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 500.0 nm.

#### Example 246

**(8S)-4',9,9'-trihydroxy-6'-(2-dimethylaminoethoxy)-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (246)**

6.1 mg (0.01159 mmol) fredericamycin (1) are suspended in 3.5 ml N,N-Dimethylaminoethanol. Under N<sub>2</sub> atmosphere, 52 mg anhydrous potassium acetate are added and heated to 80° C. After a few minutes, the suspension turns into a deep blue solution. The solution is left for 1.5 h at this temperature, and is then cooled. It is transferred onto water and

shaken out with ethyl acetate (0.1% CF<sub>3</sub>COOH). After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 2.4 mg (36% of the theoretical value); MS = 597 (M+H)<sup>+</sup>; λ<sub>max</sub>: 504.0 nm.

#### Example 247

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-(2-dimethylaminoethoxy)-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (247)**

Ten (10.0) mg (0.019 mmol) bromofredericamycin (14) are suspended in 3.0 ml ethanol. Under N<sub>2</sub> atmosphere, 50 mg anhydrous potassium acetate are added and heated to 80° C. After a few minutes, the suspension turns into a deep blue solution. The solution is left for 48 h at this temperature, and is then cooled. It is transferred onto water and shaken out with ethyl acetate (0.1% CF<sub>3</sub>COOH). After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 7.2 mg (71 % of the theoretical value); MS = 632/634 (M+H)<sup>+</sup>; λ<sub>max</sub>: 504.0 nm.

#### Example 248

**(8S)-4',9,9'-trihydroxy-6'-allyloxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (248)**

9.6 mg (0.01824 mmol) fredericamycin (1) are suspended in 3.0 ml allyl alcohol. Under N<sub>2</sub> atmosphere, 58 mg anhydrous potassium acetate are added and heated to 70° C. After a few minutes, the suspension turns into a deep blue solution. The solution is left for 2.5 h at this temperature, and is then cooled. It is transferred onto water and shaken out with ethyl acetate (0.1% CF<sub>3</sub>COOH). After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 9.2 mg (91 % of the theoretical value); MS = 566 (M+H)<sup>+</sup>; λ<sub>max</sub>: 500.0 nm.

The compounds 249, 250, 251, 252, 253, 254, 255 were generated analogously to the instructions 244-248:

#### Example 249

**(8S)-4',9,9'-trihydroxy-6'-(2-hydroxyethoxy)-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (249)**

Yield: 5.2 mg (52 % of the theoretical value); MS = 569 (M)+;  $\lambda_{\max}$ : 499.0 nm.

#### Example 250

**(8S)-4',9,9'-trihydroxy-6'-benzyloxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (250)**

Yield: 10.2 mg (99 % of the theoretical value); MS = 616 (M+H)+;  $\lambda_{\max}$ : 504.0 nm.

#### Example 251

**(8S)-4',9,9'-trihydroxy-6'-cyclopropylmethoxy-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (251)**

Yield: 12.9 mg (99 % of the theoretical value); MS = 580 (M)+;  $\lambda_{\max}$ : 500.0 nm.

#### Example 252

**1-Desoxy-5-C-[(8R)-4',9,9'-trihydroxy-6'-ethoxy-1,1',3',5',8'-penta-oxo-1,1',2,3',5',6',7',8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]pentitol (252)**

Yield: 2.0 mg (20 % of the theoretical value); MS = 622 (M+H)+;  $\lambda_{\max}$ : 499.0 nm.

#### Example 253

**(8S)-4',9,9'-trihydroxy-6'-(2-t-butoxycarbonylaminoethoxy)-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (253)**

Yield: 12.9 mg (99 % of the theoretical value); MS = 669 (M)+;  $\lambda_{\max}$ : 500.0 nm.

#### Example 254

**(8S)-4',9,9'-trihydroxy-6'-(2-N,N-diisopropylaminoethoxy)-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (249)**

Yield: 5.8 mg (48 % of the theoretical value); MS = 653 (M+H)+;  $\lambda_{\max}$ : 500.0 nm.



**Example 255**

**1-Desoxy-5-C-[(8R)-4',9,9'-trihydroxy-6'-ethoxy-1,1',3',5',8'-penta-1,2,3,5,6,7,8'-octahydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]pentitol (255)**

Yield: 5.5 mg (50 % of the theoretical value); MS = 594 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 500.0 nm.

**Example 256**

**(8S)-4',9,9'-trihydroxy-6'-(2-bromoethoxy)-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (256)**

10.6 mg (0.02014 mmol) fredericamycin (1) are suspended in 2.0 ml bromoethanol. Under N<sub>2</sub> atmosphere, 150 mg anhydrous potassium acetate are added and heated to 120° C. After a few minutes, the suspension turns into a deep blue solution. After 12 hours, addition of another 150 mg potassium acetate. The solution is left for another 12 h at this temperature, and is then cooled. It is transferred onto water and shaken out with ethyl acetate (0.1% CF<sub>3</sub>COOH). After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 11.5 mg (99 % of the theoretical value); MS = 632/634 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 499.0 nm.

**Example 257**

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-cyclopropylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (257)**

Five (5.0) mg (7.5  $\mu$ mol) 5-iodofredericamycin (15) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.64 mg (11.2  $\mu$ mmol) cyclopropylamine, it is stirred at room temperature for 3 h. Excess cyclopropylamine and DMF are removed at high vacuum. After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 5.1 mg (99 %); MS = 691:3 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

**Example 258**

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-n-butylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (258)**

Five (5.0) mg (7.5  $\mu\text{mol}$ ) 5-iodofredericamycin (15) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.82 mg (11.2  $\mu\text{mmol}$ ) n-butylamine, it is stirred at room temperature for 20 h. Excess n-butylamine and DMF are removed at high vacuum. After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 5.3 mg (99 %); MS = 707.3 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 259

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-n-butylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (259)**

Five (5.0) mg (8.1  $\mu\text{mol}$ ) 5-bromofredericamycin (15) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.89 mg (12.2  $\mu\text{mmol}$ ) n-butylamine, it is stirred at room temperature for 20 h. Excess n-butylamine and DMF are removed at high vacuum. After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 5.3 mg (99 %); MS = 659.4/661.4 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 260

**(8S)-4',9,9'-trihydroxy-6'-cyclopropylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (260)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 2.12 mg (37.2  $\mu\text{mmol}$ ) cyclopropylamine, it is stirred at room temperature for 2 h. Excess cyclopropylamine and DMF are removed at high vacuum. After drying and concentration, a chromatographically homogenous red powder is left.

Yield: 5.1 mg (99 %); MS = 565.4 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 510.0 nm.

#### Example 261

**(8S)-4',9,9'-trihydroxy-6'-anilino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (261)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 3.46 mg (37.2  $\mu\text{mmol}$ ) aniline and 37.2  $\mu\text{g}$  stannous(IV)chloride (1.0 M in  $\text{CH}_2\text{Cl}_2$ ), it is heated to 60° C. The reaction mixture is stirred for 24 h, and then excess diethanolaminomethyl polystyrene resin is added. Stir for 1 h. Exhaust off the resin and wash

with DMF. The organic phase is concentrated at high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.5 mg (99 %); MS = 601.1 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 262

**(8S)-4',9,9'-trihydroxy-6'-piperidino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (262)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 3.16 mg (37.2  $\mu\text{mmol}$ ) piperidine, it is stirred for 22 h at room temperature. Excess amine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.5 mg (99 %); MS = 593.4 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 263

**(8S)-4',9,9'-trihydroxy-6'-dimethylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (263)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 1.67 mg (37.2  $\mu\text{mmol}$ ) dimethylamine (2M in MeOH), it is stirred for 4 h at room temperature. Excess amine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.5 mg (99 %); MS = 553.6 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 526.0 nm.

#### Example 264

**(8S)-4',9,9'-trihydroxy-6'-isopropylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (264)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 2.19 mg (37.2  $\mu\text{mmol}$ ) isopropylamine, it is stirred for 4 h at room temperature. Excess amine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.2 mg (99 %); MS = 567.3 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

**Example 265**

**(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-1,1'-3',5',8'(2H)-pentone (265)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.34 mg (11.1  $\mu\text{mmol}$ ) methylamine (2M in  $\text{CH}_3\text{OH}$ ), it is stirred for 19<sup>h</sup> at room temperature. Excess amine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.0 mg (99 %); MS = 539.2 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

**Example 266**

**(8S)-5-iodo-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-1,1'-3',5',8'(2H)-pentone (266)**

Five (5.0) mg (7.5  $\mu\text{mol}$ ) 5-iodofredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.28 mg (9.0  $\mu\text{mmol}$ ) methylamine (2M in  $\text{CH}_3\text{OH}$ ), it is stirred for 2 h at room temperature. Excess amine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.0 mg (99 %); MS = 665.2 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 492.0 nm.

**Example 267**

**(8S)-4',9,9'-trihydroxy-6'-morpholino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-1,1'-3',5',8'(2H)-pentone (267)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 3.24 mg (37.2  $\mu\text{mmol}$ ) morpholine, it is stirred for 18 h at room temperature. Excess amine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.5 mg (99 %); MS = 595.5 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 518.0 nm.

**Example 268**

**(8S)-4',9,9'-trihydroxy-6'-amino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[*g*]isoquinoline-8,2'-cyclopenta[*b*]-naphthalene]-1,1'-3',5',8'(2H)-pentone (268)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.67 mg (37.2  $\mu\text{mmol}$ ) ammonia (2M in EtOH), it is stirred for 24 h at room temperature. Excess ammonia and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 4.8 mg (99 %); MS = 525.4 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 504.0 nm.

#### Example 269

**(8S)-4',9,9'-trihydroxy-6'-pyrrolidino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (269)**

Five (5.0) mg (9.3  $\mu\text{mol}$ ) fredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.99 mg (13.9  $\mu\text{mmol}$ ) pyrrolidine, it is stirred for 19 h at room temperature. Excess amine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.3 mg (99 %); MS = 579.2 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 554.0 nm.

#### Example 270

**(8S)-5-bromo-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1,1'-3',5',8'(2H)-pentone (270)**

Five (5.0) mg (8.1  $\mu\text{mol}$ ) 5-bromofredericamycin (1) are dissolved under argon in 1.0 ml anhydrous DMF. After addition of 0.70 mg (12.2  $\mu\text{mmol}$ ) cyclopropylamine, it is stirred for 5 h at room temperature. Excess cyclopropylamine and DMF are removed in high vacuum. A chromatographically homogenous red powder is left.

Yield: 5.0 mg (99 %); MS = 643.4/645.4 (M+H)<sup>+</sup>;  $\lambda_{\text{max}}$ : 492.0 nm.

#### Example 271

**2-[Acetyl]-3-[(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]ethene (271)**

79.5 mg (479  $\mu\text{mol}$ ) (2-oxo-propyl)-phosphonic acid dimethylester are dissolved under argon in 8 ml absolute pyridine, and 60.2  $\mu\text{l}$  (479  $\mu\text{mol}$ ) 1,1,3,3-tetramethylguanidine are added at 0° C. After 5 minutes, 80.0 mg (159.7  $\mu\text{mol}$ ) fredericamycin aldehyde (4) is added at 0° C.

After 2 hours, 100 ml 1 M hydrochloric acid are added, and the supernatant is sucked off from the precipitate. Dry under high vacuum.

Yield: 60.0 mg (69 % of the theoretical value);  $M/e = 542.2$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 272

**2-[Bromoacetyl]-3-[(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]ethene (272)**

Fifty (50.0) mg (92.4  $\mu\text{mol}$ ) acetyl fredericamycin are dissolved under argon in 5 ml absolute DMF, and then 36.9 mg (231.1  $\mu\text{mol}$ ) bromine as a 1 M bromine solution in DMF are added under exclusion of light. It is stirred for 23 h under exclusion of light, and then 100 ml water are added. The precipitate is sucked off and dried under high vacuum.

Yield: 57.0 mg (87 % of the theoretical value) red powder;  $M/e = 697.9/699.9/701.9$ ;  $M^+$ ;  $\lambda_{\max}$ : 504.0 nm.

#### Example 273

**2-[2-Amino-thiazole-4-yl]-3-[(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]ethene (273)**

Twenty (20.0) mg (28.7  $\mu\text{mol}$ ) bromoacetyl fredericamycin (273) are dissolved under argon in 4ml absolute DMF. At room temperature, first 3.3 mg (43.0  $\mu\text{mol}$ ) thiourea, and then 20 mg IR120 H<sup>+</sup> are added. After 2 hours, it is filtered off the resin, and added to 50 ml water. The precipitate is dried under high vacuum. Red powder.

Yield: 18.0 mg (93 % of the theoretical value);  $M/e = 676.1/678.1$ ;  $(M+H)^+$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 274

**2-[2-Phenyl-thiazole-4-yl]-3-[(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]ethene (274)**

Five (5.0) mg (7.2  $\mu\text{mol}$ ) bromoacetyl fredericamycin (273) are dissolved under argon in 1 ml absolute DMF. At room temperature, first 1.5 mg (10.8  $\mu\text{mol}$ ) thiobenzamide, and then 5 mg IR120 H<sup>+</sup> are added. After 3.5 h, addition of hydrazinosulfonyl resin, and stirring for 2 h. It is filtered off the resin, and added to 10 ml water. The precipitate is dried under high vacuum. Red powder.

Yield: 3.0 mg (57 % of the theoretical value);  $M/e = 737.2/739.2$ ;  $(M+H)$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 275

**2-[2-Acetylamino-thiazole-4-yl]-3-[(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]ethene (275)**

Five (5.0) mg (7.2  $\mu$ mol) bromoacetyl fredericamycin (273) are dissolved under argon in 1 ml absolute DMF. At room temperature, first 1.3 mg (10.8  $\mu$ mol) acetylthiourea, and then 5 mg IR120 H<sup>+</sup> are added. After 22 h, addition of hydrazinosulfonyl resin, and stirring for 2 h. It is filtered off the resin, and added to 10 ml water. The precipitate is dried under high vacuum. Red powder.

Yield: 2.0 mg (39 % of the theoretical value);  $M/e = 718.3/720.4$ ;  $(M+H)$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 276

**2-[2-Methyl-thiazole-4-yl]-3-[(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-3-yl]ethene (276)**

Five (5.0) mg (7.2  $\mu$ mol) bromoacetyl fredericamycin (273) are dissolved under argon in 1 ml absolute DMF. At room temperature, first 0.81 mg (10.8  $\mu$ mol) thioacetamide, and then 5 mg IR120 H<sup>+</sup> are added. After 2 h, addition of hydrazinosulfonyl resin, and stirring for 2 h. It is filtered off the resin, and added to 10 ml water. The precipitate is dried at high vacuum. Red powder.

Yield: 3.0 mg (62 % of the theoretical value);  $M/e = 675.2/677.2$ ;  $(M+H)$ ;  $\lambda_{\max}$ : 492.0 nm.

#### Example 277

**(8S)-4',9,9'-trihydroxy-6'-methylamino-3-[(1E,3E)-penta-1,3-dienyl]-6,7-dihydrospiro[cyclopenta[g]isoquinoline-8,2'-cyclopenta[b]-naphthalene]-1-thio-,1'-3',5',8'(2H)-tetrone-thiofredericamycin (277)**

Ten (10.0) mg (18.5  $\mu$ mol) fredericamycin (1) are dissolved under argon in 2 ml absolute pyridine. After addition of 20.5 mg (92.5 mmol) phosphorous-V-sulfide, it is heated for 12 h to 60° C. Addition of another 20.5 mg (92.5 mmol) phosphorous-V-sulfide. According to HPLC (acetonitrile/water CF<sub>3</sub>COOH), the reaction was complete after 1 h. It is transferred onto water and shaken out with ethyl acetate. Dry and concentrate. Purple-red powder.

Yield: 5.0 mg (49 % of the theoretical value);  $M/e = 55.7$ ;  $(M+H)$ ;  $\lambda_{\max}$ : 504.0 nm.

**Example A**

Water solubility of the fredericamycin derivatives

The water solubility of the various fredericamycin derivatives can be determined in a 0.9% NaCl solution with a pH of 7.

The compounds (22) and (3) dissolve very well. Compound (6) dissolves well, and compounds (2), (10), and (13) are soluble. Compounds (5), (7), (11) and (12) are sufficiently and markedly better soluble than fredericamycin (compound (1)).